Iron and Steel Engineer

Established 1907 as Proceedings of A. I. & S. E. E.

J. F. KELLY, EDITOR

CONTENTS

Volume IX. APRIL, 1932. Number IV.

Messages From Past Presidents of the A. I. & S. E. E.—by J. J. Booth, W. S. Hall, D. M. Petty, L. R. Palmer, A. J. Standing, E. Friedlander, W. T. Snyder, F. D. Egan, B. R. Shover, F. O. Schnure, O. R. Jones, R. B. Gerhardt, J. C. Reed, B. W. Gilson, C. W. Parkhurst, J. Farrington, S. S. Wales, F. W. Cramer and C. S. Proudfoot 153

The Design of Industrial Equipment in Welded Steel—by Everett Chapman, Director of Engineering and Research, Lukenweld, Inc., Coatesville, Pa. 161

Discussion—The Design of Industrial Equipment in Welded Steel—discussion presented by F. O. Schnure, E. Chapman, J. C. Reed, H. P. Clever, L. F. Coffin, N. C. Bye, W. N. Horko, A. H. Yoch, W. J. Diederich 168

Magnetic Testing of Iron and Steel—by A. V. de Forest, Magnetic Physicist, Welding Engineering and Research Corporation, New York, N. Y. 170

Discussion—Magnetic Testing of Iron and Steel—discussion presented by F. O. Schnure, A. V. de Forest, C. L. Lane, K. M. Raynor, B. J. Wilson, W. N. Horko, W. A. Smiley, Dr. G. S. von Heydekampf, Lieut. A. Willink, G. R. Toon, E. Spring, J. Miller, F. B. Foley, and J. A. Lawless 173

Asbestos in Industrial Friction Materials—by J. W. Hemphill, Jr., General Power Products Dept., Johns-Manville Sales Corp., New York, N. Y. 176

Discussion—Asbestos in Industrial Friction Materials—discussion presented by C. F. Ogren, F. C. Stanley, J. W. Hemphill, Jr., J. L. Brown, B. H. Kersting, J. A. Burg, R. F. Kintzing, J. L. Lundberg, C. B. Withgott 180

Lubrication—Past, Present and Future 186

Lubricating Steam Cylinders 187

Combustion Topics 190

Savings Accomplished with Foot-Operated Master Switches—by W. H. Burr, Electrical Superintendent, Lukens Steel Co., Coatesville, Pa. 193

Items of Interest 195

A. I. & S. E. E. Convention and Exposition II

Editorial III

Index to Advertisers IV

Published Monthly by

Association of Iron and Steel Electrical Engineers

BOARD OF DIRECTORS—1931-1932

President, J. J. BOOTH, Electrical Supt., National Tube Company, Gary, Ind.

1st Vice Pres., J. D. Donovan, Electrical & Mechanical Supt., Republic Steel Corporation, Massillon, Ohio.

2nd Vice Pres., W. E. Miller, Electrical Supt., Bethlehem Steel Company, Johnstown, Pa.

Treasurer, W. H. Burr, Electrical Supt., Lukens Steel Company, Coatesville, Pa.

Secretary, William Jackson, Electrical Supt., Homestead Works, Carnegie Steel Company, Munhall, Pa.

Past Pres., F. O. Schnure, Electrical Supt., Bethlehem Steel Company, Sparrows Point, Md.

Past Pres., F. W. Cramer, Chief Electrical Engineer, Republic Steel Corporation, Youngstown, Ohio.

Director at Large, J. H. Van Campen, Chief Engineer of Youngstown District, Republic Steel Corporation, Youngstown, Ohio.

Honorary Director, James Farrington, Electrical Supt., Wheeling Steel Corporation, Steubenville, Ohio.

Director, J. H. Wagner, Electrical Supt., Acme Steel Company, Chicago, Illinois.

Director, K. M. Raynor, Electrical Supt., Bethlehem Steel Company, Bethlehem, Pa.

Director, Birger Thele, Electrical Dept., Tennessee Coal Iron & R. R. Company, Fairfield, Ala.

Director, J. A. Clauss, Chief Engineer, Great Lakes Steel Corporation, Detroit, Mich.

Director, G. R. Carroll, Electrical Supt., Jones & Laughlin Steel Corporation, Aliquippa, Pa.

Director, C. C. Pecu, Lubrication Engineer, Bethlehem Steel Company, Lackawanna, N. Y.

Director, G. T. Hollett, Combustion Engineer, Illinois Steel Company, South Chicago, Ill.

Director, J. F. Hunter, Safety Engineer, Carnegie Steel Company, Pittsburgh, Pa.

Honorary Director, E. Friedlander, Pittsburgh, Pa.

Managing Director, John F. Kelly, Empire Building, Pittsburgh, Pa.

Entered as second-class matter January 25th, 1924, at Pittsburgh, Pa., under the Act of March 3rd, 1879.
Subscription Price $5.00 per Year. Single Copy $1.00.

A. I. & S. E. E.
CONVENTION AND EXPOSITION

AUSPICES

Lubrication, Combustion, Electrical, Mechanical and Safety Engineering Divisions

JUNE 20-21-22-23, 1932

Pittsburgh, Pa. William Penn Hotel

Exhibits

Steel Mill Equipment used to process and produce Iron and Steel

Technical Sessions

Tentative Program

PAPERS AND DISCUSSIONS TO BE PRESENTED ON:

Electrical Developments.

Welding.

Ladle Cranes.

High Tension Power Line Safety.

Standardized Control Apparatus.

Devices Actuated by Light.

Design and Performance of a Fully Compensated D.C. Machine and What It Means to the Steel Industry.

Determination of Motor Capacity for Main Roll Drives.

The Substitution of Fabricated Steel for Castings.

High Pressure Boiler Plants.

Mechanical Transmission of Power.

Round Table Discussion in Connection with Fuel Efficiency Records.

Air Cooled Boiler Furnace Walls.

Water Cooled Boiler Furnace Walls.

Maintenance and Care of Recording Instruments Used in Steel Plants, in Connection with Boilers, Open Hearth Furnaces, Heating Furnaces, Soaking Pits, Gas Producers, etc.

Lubrication of Steel Mill Auxiliaries.

The Application of Micarta Bearings to Roll Necks.

Lubricants for Roll Necks.

Roll Neck Bearings.

Questions and Answers in Connection with Lubrication as Applied to Steel Mill Equipment.

IRON AND STEEL EXPOSITION

The Iron and Steel Exposition is sponsored, owned and controlled by the Lubrication, Combustion, Electrical, Mechanical and Safety Engineering Divisions of the Association of Iron and Steel Electrical Engineers.

The Iron and Steel Exposition will consist of Exhibits of Steel Mill Equipment used to process and produce Iron and Steel.

Over 9,000 visitors inspected the Exhibits last year and judging from interest in the Association's activities this year this number will be far exceeded.

Make arrangements for all your associates to visit this Exposition.

EDITORIAL

Association of Iron and Steel Electrical Engineers Is Twenty-five Years Old

For twenty-five years men of the steel industry have given time, energy and their talents to bequeath to their fellow workmen a knowledge of engineering and operating practices.

These men, while they never will be rewarded with success measured by dollars for their work, they have had their triumph far beyond the petty gains of money, the satisfaction of serving their fellow men and serving them well has been their reward. The Association of Iron & Steel Electrical Engineers is indebted to its twenty-five Past Presidents and all of the past executives both National and Sectional for their efforts in assisting the A. I. & S. E. E. to not only become a national but an international engineering society, devoted to service and progress to the Iron and Steel Industry.

On April 26 and 27, 1907, twenty-eight Electrical and Mechanical Engineers met at an informal gathering to inspect a special exhibit of electrical apparatus for use in Iron and Steel plants and to listen to technical discussions covering matters of general interest to the Iron and Steel Industry.

The exchange of ideas, opinions and experiences awakened these engineers to the need of closer cooperation. It was the suggestion of J. Farrington, then electrical superintendent of the LaBelle Iron Works at Steubenville, Ohio, that a national organization of the men in charge of mechanical and electrical departments of the Iron and Steel Industry be formed. Meetings were to be held at stated intervals to discuss the subjects of common interest to electrical and mechanical engineers and superintendents.

To Mr. Farrington and the twenty-seven engineers who were present at the meeting, the Association owes its present existence. It would have required quite a good deal of vision and imagination at that time to have been able to predict that the Association would grow and prosper into an international organization and that today it would enjoy the prestige and position that it now occupies.

From this modest beginning the Association of Iron & Steel Electrical Engineers has grown to be an international engineering society with members in steel plants in practically all countries of the world.

Its various engineering branches—mechanical, electrical, lubrication, combustion and safety, are recognized as the engineering authorities in the Iron and Steel Plants. They have contributed to the Industry, standards, codes, specifications, designs, methods, processes, research, experiments, tests and thousands of open discussions covering the selection, design, installation, operation and maintenance of the equipment used to process and produce Iron and Steel.

Over 10,000 pages of engineering data and information has been distributed and placed in the hands of the engineering personnel and operating executives in the Iron and Steel Plants. Attendance records indicate 250,000 at the various activities sponsored by the Association. A range of 4,500 subjects have been discussed by the engineers and operating executives in Association meetings. It is estimated that over 10,000,000 miles were traveled by the persons who participated in the Association's activities.

The Association today is composed of Sections at Cleveland, Chicago, Birmingham, Pittsburgh and Philadelphia, who have met in Buffalo, Wheeling, Youngstown, Gary, Reading, Bethlehem, Sparrows Point, Harrisburg, Ambridge, Detroit, St. Louis, Johnstown, Homestead, Duquesne, Milwaukee, East Pittsburgh, Harrison, Bear Mountain, Valley Forge, Conowingo, Riverside, Clairton, Granite City, Allenport, Aliquippa, Alliance, McKeesport, Steelton, Florence, Erie, New York, Baltimore, Steubenville, Chicago, Braddock, Indiana Harbor, Akron, Salem, Lackawanna, Lorain, Canton, Massillon, Fairfield, Ensley, Coatesville, Wilmington, Warren, McDonald and Hamilton, Canada.

There are 22 national committees functioning, namely, Standardization, Developments of Rolling Mill Practices, Special Committee on Bearings, Illumination, Papers, Editing, Membership, Welding, Electric Heat, Electrical Developments, Portable Electric Tools, Air Conditioning, Transportation, Shop Practices, Gas Producer, Gas Utilization, Steam Generation and Utilization, Liquid Fuel, Instruments and Control, Lubricant and Device Development, Special Committee on D. C. Control apparatus and Safe Practices.

The Engineers and Operating Executives who now compose the membership of the Association of Iron & Steel Electrical Engineers, have contributed to a major degree in helping the Iron and Steel Industry to enjoy its present leadership in the Industrial World. There are still many major engineering problems to be solved, principally rehabilitation of the existing equipment, which means the expenditure of hundreds of millions of dollars. The engineering skill, talent and experiences of the members of the Association of Iron & Steel Electrical Engineers will be ever active in the solution of the problems confronting their Industry.

INDEX TO ADVERTISERS

A

The Alliance Machine Company 225
Allis-Chalmers Mfg. Co. 210
American Air Filter Company, Inc. 215

B

The Baker-Raulang Company 228
The Bartlett Hayward Company 203
E. W. Bliss Co. 212
Bull Dog Electric Products Co. 197

C

Century Electric Company 226
The Clark Controller Co. Cover I
The Cleveland Crane & Engineering Co. 217
Colt's Patent Fire Arms Mfg. Co. 209
Crocker-Wheeler Electric Mfg. Co. 222
Crouse-Hinds Co. 241

D

Henry L. Doherty & Co. 231
Doubleday-Hill Electric Co. 238
Duquesne Light Company 216

E

The Electric Controller & Mfg. Co. 206
Elliott Company 198

F

The Fafnir Bearing Co. 237
Farrel-Birmingham Co., Inc. 214

G

General Electric Co. 207-211-220-21-Cover 4

H

Hyatt Roller Bearing Company 201

I

I-T-E Circuit Breaker Company Cover 3

K

Keystone Lubricating Co. 208

L

LeCarbone Company 238

M

The Martindale Electric Co. 239
Monitor Controller Company 199
Morgan Construction Company 244
The Morgan Engineering Co. 202
Morganite Brush Co., Inc. 240

N

National Carbon Company, Inc. 223
The New Departure Mfg. Company 213
The Nichols-Lintern Company 235
Norma-Hoffmann Bearings Corpn. 218

O

The Ohio Electric Mfg. Co. 236

P

Pennsylvania Transformer Company 242

R

Reliance Electric & Engineering Co. 232-33
Rockbestos Products Corporation 224
The Rowan Controller Co. 240

S

SKF Industries, Inc. 227
Stimple & Ward Co., Inc. 241
Sundh Electric Co. Cover I
Surface Combustion Corporation 231

T

The Thompson Electric Company 239
The Timken Roller Bearing Company 204-05
The Tool Steel Gear & Pinion Company 229
The Trumbull Electric Manufacturing Co. 234
Turner Engineering Company 219

U

Union Carbide and Carbon Corporation 223
The United States Graphite Company 230

W

The Wellman Engineering Co. 200
Westinghouse Electric & Mfg. Company Cover 2-243

Messages From Past Presidents of the A. I. & S. E. E.

James Farrington, Elec. Supt., Wheeling Steel Corp., Steubenville, Ohio.

J. C. Reed, Elec. Engr., Bethlehem Steel Co., Steelton, Pa.

F. P. Townsend, East Orange, N. J.

L. R. Palmer, Conservation Engr., Equitable Life Assurance Society of U. S., New York, N. Y.

B. R. Shover, Consulting Engr., Oliver Bldg., Pittsburgh, Pa.

C. W. Parkhurst, Consulting Engr., Berwind White Coal Mining Co., Philadelphia, Pa.

E. Friedlander, Kaufmann's, Pittsburgh, Pa.

O. R. Jones, Elec. Supt., Sharon Steel Hoop Co., Lowellville, Ohio.

W. T. Snyder, Supt. of Power, National Tube Co., McKeesport, Pa.

F. D. Egan, Elec. Supt., Bethlehem Steel Co., Lackawanna, N. Y.

C. A. Menk, Club Ave., South Hills, Pittsburgh, Pa.

D. M. Petty, Supt. of Service Division, Lehigh Plant, Bethlehem Steel Co., Bethlehem, Pa.

B. W. Gilson, Elec. Supt., Ohio Works, Carnegie Steel Co., Youngstown, Ohio.

E. S. Jeffries, Elec. Engr., National Forming Machine Co., Tiffin, Ohio.

W. S. Hall, Supt. Engineering & Construction, Illinois Steel Co., S. Chicago, Ill.

R. B. Gerhardt, Asst. Gen. Mgr., Bethlehem Steel Co., Steelton, Pa.

R. S. Shoemaker, Rolling Mill Superintendent, American Rolling Mill Co., Middletown, Ohio.

A. C. Cummins, Elec. Supt., Carnegie Steel Co., Duquesne, Pa.

G. H. Schaeffer, Elec. Engr., Carpenter Steel Co., Reading, Pa.

S. S. Wales, Ch. Elec. Engr., Carnegie Steel Co., Pittsburgh, Pa.

A. J. Standing, Elec. Supt., Saucon Div., Bethlehem Steel Co., Bethlehem, Pa.

C. S. Proudfoot, Gen. Mgr., Vanadium Corp. of America, Niagara Falls, N. Y.

F. W. Cramer, Ch. Elec. Engr., Republic Steel Corp., Youngstown, Ohio.

F. O. Schnure, Elec. Supt., Bethlehem Steel Co., Sparrows Point, Md.

J. J. Booth, Elec. Supt., National Tube Co., Gary, Ind.

▲

By J. J. BOOTH
President of the A. I. & S. E. E.—1931-32

On the 26th day of April, 1932, the Association of Iron and Steel Electrical Engineers will celebrate its twenty-fifth Anniversary.

While the period 1931 and 1932 has been one of extreme difficulties, we are proud that our Association has weathered the storm as well as it has. Following the precedent of our progressive manufacturers of taking advantage of quiet times, our Association has not been asleep, and we are putting forth every effort to broaden the activities of the Association, and maintain the helpfulness which has made it so valuable in the past. We believe this year, as in every past year, our Association has given its members more than any other technical society, in the way of engineering information.

Each of the sections, Pittsburgh, Cleveland, Chicago, Philadelphia and Birmingham are putting over excellent, well attended meetings, and neither the quality of the presentations nor the support given them seems to have diminished this year.

Some of the outstanding features of the year may be classed somewhat as follows:

Special papers and programs on photo-electric cells, with varied applications in the iron and steel industry.

Reversing synchronous motor driving rolling mills.

Symposiums on safety equipment to prevent hot metal spills, covering both mechanical and electrical hook-ups.

Symposium on sheet mill practices which was attended by 700 persons.

The work of the committees this year, of necessity has had to be done at long range, due to curtailed operations and economic programs. Nevertheless the committee chairmen and committees have their work well in hand, and are making advancement.

The Standardization of Control Symbols Committee has made and are making excellent progress along the line of standardizing magnetic control for steel mill service. We hope that before the close of this year, we will have adopted a fairly complete set of control standards, satisfactory to the manufacturers as well as to the steel mill users.

The Lubrication Committee started last year, has made wonderful strides and we are looking forward to even greater accomplishments within the next year. We all realize too well the present economic conditions, and the fact that few installations are being made, but in those that are being installed and those being planned, automatic lubrication is given prime consideration. We venture to say that few mills in the future will be installed without automatic lubrication, much to the credit of the manufacturers engaged in this line of industry, and our Association for pushing forward this activity.

The Combustion Engineering Division is fast coming to the front with both Electrical and Mechanical Control for every application where proper combustion is a factor. This applies to heat treating furnaces of small and large capacity, open hearth furnaces, continuous heating furnaces, reheating furnaces, etc. The personal element or man equation is fast being eliminated where exactness in control is required.

Your Association has just completed and distributed a complete set of standard specifications for steel mill cranes. While we confidently believe that this set of specifications is one of the best, if not the best for steel mill cranes we have ever produced, a large majority of our membership feel we should have a set of specifications for light duty cranes. The real reason for sponsoring this light duty crane specification is because of the fact that in many instances there are applications where a light duty crane would fill the requirements without the expenditure of extra money for the steel mill appliances. This also will eliminate in the case of manufacturers quoting on cranes of this nature, some manufacturers quoting on heavy duty cranes while others quote on light duty cranes at a lower figure. The main object of the light duty specifications will be to have all bidders quote on practically the same type of equipment.

While the Association is justly credited with the fathering of safety in the United States and that much has been accomplished since this program was conceived, there is not a day from the standpoint of safety that the Association and steel makers are not endeavoring to make working conditions more safe. At the present time the next major move relative to safety will be a very complete study regarding high tension design, installation and maintenance. We have at the present time both low and high tension rules for handling electrical equipment in local steel mills, but with the advent of purchased power from the utility companies we have had to arrive at a safe method of tying in this power with the local steel plant. A major portion of the new rules will be directed to this one point—the interconnection between public utility and steel mills.

The 1932 Convention and Exposition we hope will be one of the best that has ever been held despite the present conditions. Your Executive Officers and Board of Directors have given this matter very careful study as to what would be the proper procedure and after considerable time spent on this matter, it was decided that without a question the Association should hold a Convention. Consequently we expect to hold the 1932 Convention in the William Penn Hotel, Pittsburgh, June 20 to 23, inclusive, and we feel that with the aid of the manufacturers who have so nobly co-operated with us in the past this will be one of our best Conventions. One of the major reasons for deciding to hold the Convention and the most encouraging words we have received since this decision has been handed out is that of all times, the Association and manufacturers should advertise at the present time, when business conditions are at such a low ebb. It is very evident that heavy expenditures should be curtailed this year and that manufacturers should advertise their newest and up-to-date equipment and that the Convention as never before should be used for the exchange of friendship and latest technical developments and information as never before.

Our Association, through its meetings and through its official periodical, The Iron and Steel Engineer, endeavors to perform its duty of disseminating to its members, news of the latest and best in the field of Iron and Steel Engineering, helping to make our mills safe and efficient, with maximum production at minimum cost.

▲

By W. S. HALL
President of the A. I. & S. E. E.—1922

The success of an organization of any kind, whether it is for pleasure, education, or financial return, can be measured only by its results over a period of years.

In looking back over the years which this Association has been in existence, it will be recalled by many the early struggles which were encountered to put the Association upon a foundation from which it was possible to develop to its present status. As to how well these trying conditions were met can be judged by the results.

The Association today stands in a very enviable position compared with other similar organizations, not only from the standpoint of carrying out the purpose of the Association, but financially as well. This position has been attained not only by adhering strictly to problems within the scope of the purpose of the Association, but also by leaving the management and control of the Association in the hands of those actually engaged in steel mill work. Full credit should also be given to the electrical manufacturers and others whose representatives have always had the best interests of the Association at heart, for without their co-operation, the Association could not have attained the position that it enjoys today.

We can point with pride to the work of this Association when purchasing electrical apparatus, it being quite evident that the customer's requirements are more clearly understood by the electrical manufacturers, through the efforts of this Association, than is the case when apparatus of another nature is being purchased. This experience leads us to believe that both the manufacturer and purchaser have gained materially by our efforts.

While it is true that the Association is expanding somewhat its field of activities, this expansion has only been attempted where it was felt that the greatest need existed and where the problems were those in which a steel plant engineer was vitally interested. The same policy of keeping the control of the Association in the hands of the steel plant engineers and at the same time co-operating with representatives of the apparatus manufacturers, is being applied in this expansion program, and from the results thus far obtained, we have reason to believe that the attempts will prove equally as successful as the work carried on by the Association in the early days when only electrical problems were considered.

It has been mentioned that the success of the Association was largely due to the policies adopted from time to time. The Officers and Board of Directors, since the organization of the Association, have been continually changing, with the result that the carrying out of these established policies has been largely in the hands of the Managing Director, who has been continuously in charge since the early years of the Association. His efforts in carrying out the policies of the Association, many of which originated with him, are responsible, to a large degree, for the Association's success.

▲

By D. M. PETTY
President of the A. I. & S. E. E.—1919

Twenty-five years of service to the Steel Industry by the Association of Iron and Steel Electrical Engineers is another proof of the validity of the statement "In union there is strength."

By united action the Association has been able to accomplish many things for the Steel Industry that would have been very difficult if each engineer had worked alone.

It inaugurated the first inter-company safety drive and organized the National Safety Council to carry on that good work.

It demanded a better direct current series wound motor, and the electrical manufacturers answered with the mill type motor, and after further work a mill type motor is now available with standardized mounting dimensions.

It materially advanced the date and standardized the application of ball and roller bearings to motors.

But the greatest service the Association renders to

the Steel Industry is in providing a meeting place where the engineers of the Industry can discuss their problems not only from the floor of the open meeting, but also as one personal friend to another.

United action for the good of the Industry should continue to be the watchword as the Association goes into its second Quarter Century.

▲

By L. R. PALMER
President of the A. I. & S. E. E.—1910-11

In responding to the request to join with other past presidents of the Association of Iron and Steel Electrical Engineers in a contribution of some reminiscences for the twenty-fifth anniversary of the Association, I will limit my comments to that phase of our early history in which I was most interested; that is, our pioneer activities in the development of organized industrial safety.

It is more than twenty years since I served as President of the Association of Iron and Steel Electrical Engineers, and I am of the opinion that only a relatively few of the present members are intimately familiar with the early history of our organization.

From its inception in 1907 the Association of Iron and Steel Electrical Engineers made accident prevention an outstanding feature of its activities. It was only natural that we should give serious thought to this subject, owing to the hazardous nature of our work at that time.

On November 26, 1908, I wrote a letter to Mr. J. C. Reed, then President of the Association, suggesting the appointment of a safety committee within our organization for the purpose of studying accidents occurring in the iron and steel industry. Such a committee was established, and it became the duty of this committee to develop the safety programs for the annual meetings of the Association. These safety programs grew to be a predominating feature of the conventions. In fact, according to the October 24, 1910, issue of "Industrial World," Safety was "The main theme of discussion during the four days' session" of our 1910 annual meeting.

The officers of the Association of Iron and Steel Electrical Engineers, having received wholehearted cooperation in their pioneer efforts toward the development of organized safety, were encouraged to extend their endeavors toward establishing a separate safety organization, national in scope, that could better serve as a co-ordinating agency and a general clearing house for all phases of accident prevention. To this end it was decided to hold a joint conference at its next convention, believing that the importance and magnitude of the subject precluded its being organized within the Association.

With the object of obtaining the active participation of all agencies and individuals interested in accident prevention, a personal survey was made of the field by a representative of the Association, who traveled some four thousand miles and returned with the favorable report that all were in accord with this suggestion. The success of such a joint meeting was unquestionably assured.

This First Co-operative Safety Conference was called in Milwaukee, Wis., September 30 to October 5, 1912, and a comprehensive program was developed, including the following sessions: Federal, States, Mines, Transportation, Manufacturers, Allied Associations, and Iron and Steel. President B. R. Shover, in opening the Iron and Steel Session, spoke as follows:

"The subject assigned to me is 'Co-operation' which I am sure all will agree symbolizes the spirit of this Congress.

"It was this same spirit that prompted the A. I. and S. E. E. to extend the invitation to which you so heartily responded. It has been our 'trade mark' from the first. It is the natural bond between the man and the master, the state and the nation—none high nor low can succeed without it.

"This session closes THE FIRST CO-OPERATIVE SAFETY CONGRESS. Its success has exceeded our highest hopes. From it may many annual Safety Congresses grow, each greater than the other and all 'permeated', 'saturated', 'energized' with CO-OPERATION."

At the annual banquet of the Association of Iron and Steel Electrical Engineers in Milwaukee the following resolution (formulated by Gano Dunn, then Chief Engineer of the Crocker-Wheeler Company) was adopted:

"WHEREAS, The Association of Iron and Steel Electrical Engineers regarding as worthy of particular attention the hazards to life involved in electrical operations in steel mills, and appreciating the importance of the general safety movement not only in electrical engineering, but also in the steel industry as a whole, and in all the other varied and important industries of our country, and having met with such prompt co-operation in their proposals to establish a national organization devoted to securing increased safety to human life, have reached the conclusion that such an organization can best be brought about by action at this joint meeting of the Association of Iron and Steel Electrical Engineers and the Co-operative Safety Congress, and it is, therefore, hereby

"RESOLVED, That the President of the Association of Iron and Steel Electrical Engineers be requested to take the first steps toward the formation of a national organization for the promotion of safety to human life by appointing a Committee on Permanent Organization, which shall contain representatives of the Federal and State Agencies already established to supervise conditions of safety in our industries, and shall also contain representatives from the Mining, Transportation and Manufacturing Industries of the United States, and be it further

"RESOLVED, That the Committee so appointed shall be and hereby is authorized by this Congress to organize and to create a permanent body devoted to the promotion of safety to human life in the industries of the United States; this Committee to have authority to call future Congresses of Safety, increase its membership if it so desires, and to do such other acts as will promote the object for which it is established."

The Committee appointed consisted of the following members:

Dr. Charles P. Neill, U. S. Commissioner of Labor.
Dr. Joseph A. Holmes, Director, Bureau of Mines.
Charles C. McChord, Interstate Commerce Commission.
F. W. Houk, Commissioner of Labor, Minnesota.
Dr. Lucian W. Chaney, Department of Commerce and Labor.

H. M. Wilson, Bureau of Mines.
Dr. M. J. Shields, National Red Cross.
C. W. Price, Wisconsin Industrial Commission.
James T. McCleary, Iron and Steel Institute.
John Kirby, Jr., National Association of Manufacturers.
R. C. Richards, Chicago and North Western Railway
C. L. Close, U. S. Steel Corporation Safety Committee.
F. C. Schwedtman, National Association of Manufacturers.
David Van Schaack, Aetna Life Insurance Co.
R. J. Young, Illinois Steel Company.
Lew R. Palmer, Association of Iron and Steel Electrical Engineers.

Thus was launched what has come to be recognized as a national institution—the NATIONAL SAFETY COUNCIL.

That the part played by the steel industry in the pioneer development of the Industrial Safety Movement was appreciated, is evidenced by the resolution passed at the Milwaukee Congress, which reads as follows:

"RESOLVED, That the members of the Transportation Session of the First Co-operative Safety Congress extend their hearty and sincere thanks and appreciation to the ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS for the initiative which they have taken in calling together this Congress, and their effort to make the same successful."

In acknowledgment of the pioneer safety work of the United States Steel Corporation under progressive leadership, Judge Elbert H. Gary was made the first honorary member of the National Safety Council; also, at a later date, the Executive Committee of the Council officially designated the Association of Iron and Steel Electrical Engineers as an honorary member of the Council as evidence of its "filial devotion." Furthermore, the first three presidents of the Council were drawn from the steel industry—Campbell, Morey and Palmer.

Those of us who have been privileged to follow intimately the growing activities of the National Safety Council from its inception believe ourselves justified in the opinion that the Association of Iron and Steel Electrical Engineers should credit the part it played in the development of the National Safety Council as one of its greatest achievements. It was a pioneer effort, and "they builded even better than they knew."

▲

By A. J. STANDING
President of the A. I. & S. E. E.—1928

With this issue of the Iron and Steel Engineer we mark the Twenty-fifth Anniversary of the inception of the Association of Iron and Steel Electrical Engineers. This birthday coming as it does at a peculiarly significant period in the life of the Steel Industry brings with it a challenge to all our members and associates to think not in terms of our past accomplishments in the Industry but to think clearly in terms of the present and the future and to analyze the problems which these times present to us.

Our Association was brought into being as a direct result of the realization on the part of the leaders responsible for Steel Mill Electrical operation twenty-five years ago, of their interdependence on one another for experience, advice and information that would enable them to more clearly understand the then new problems being presented by the introduction of Electrical equipment into the Steel Industry. That its service in the main has been distinctly of benefit to all who have had a part in its growth need not be questioned nor must the value of our Association to present day problems be permitted to in any degree fall short of the progress of the past.

It is true that we today do not have to repeat the steps taken or review the knowledge gained throughout these intervening years but we have just as certainly to assume our responsibility for the progress which must belong to our Industry as we emerge from this present temporary period of retardation. Just as our infant Association was able to serve, so must our more mature organization through its many new and varying sources of information be prepared to serve us under the newer conditions which are confronting us today and which will, in a large measure, govern the successes which will come to all Industry in the future.

Old problems of operation and production become now problems of economic operation and production of products best fitted to the requirements of our times and the demands of the trade we serve. It will be part of our function to help adapt present equipment to the changes in our production that must be introduced in order to keep our Plant in line with the new products that we must be prepared to furnish if we are to profit by the revival of trade which will follow the economic adjustment toward which all governmental and financial agencies are working today.

The industrial depression of the past two years has undoubtedly curtailed somewhat the functions of our Association but with the gradual resumption of business I feel that the managements of our Companies will again recognize the advantages accruing from the participation of their engineers in the work and developments sponsored by this Association particularly along the lines of newer endeavors to create more general interest and understanding on the part of our members in lines of economic operations other than in their own particular line of activity.

The twenty-five years, now history with our Association, were replete with periods of unusual interest including the unprecedented upheaval of the World War with all its ramification of problems, demands and accomplishments involving conditions never before encountered in the Steel Industry. These seemingly impossible demands for quality and quantity production of unlimited varieties of steel for all purposes were met and executed in a generally satisfactory manner.

What of the next Twenty-five years? Judging from the present it is unquestionably true that the first five years or more will be influenced by the gradual re-establishment of business on a basis that will reflect the principles of safe growth as distinguished from the unsound inflation of 1929. Let us lend our untiring efforts to help bring about the readjustment that must precede the return of prosperity.

Those of us who have been privileged to serve on the Board and as President of this Association will maintain our interest in its efforts and we realize that there are always new leaders being prepared to help

guide the affairs along the lines of most benefit to the industry which has given us its loyal support. Our wish for the years to come is that we may be prepared to serve better than we have in the past.

▲

By E. FRIEDLANDER
President of the A. I. & S. E. E.—1914

At a monthly meeting of the Pittsburgh Section of our Association in 1916, W. T. Snyder, the President, portrayed a gloomy picture of the Association. He complained about the active members not being present at meetings, not doing their full share in presenting papers and not taking sufficient interest in general in their organization. At this time the Association was expanding very slowly and it was suggested that branches, other than the one in Philadelphia be organized; the membership be enlarged by taking in industries, other than the Iron and Steel and that the dues be increased. The high cost of printing our proceedings and the method employed to improve our financial condition by selling advertising space were also criticised.

In view of the deplorable condition of the organization and the tantalizing indifference and inattentiveness of the membership to the aims and principles of the society, the above suggestions, together with many others of every note and description were offered to stimulate the interest of the individual members. The alternative was complete failure.

Today, 16 years after W. T. Snyder presented his picture of gloom, the Association of Iron and Steel Electrical Engineers, finds itself in the front rank, yet, the youngest in the family of Engineering Societies. We have every reason to be proud of the progress our Association has made in the last 16 years.

The large diversity in the subjects treated in the Technical papers which have been presented before the Association, shows that our field is enlarging in all directions. The great activity of the Association, the enormous amount and fine quality of the work which it produces each year, should guarantee for the Association a glorious future, full of prosperity and progress.

The Association is the proud Father of the Safety Movement in this country. Through the untiring efforts of our Chairman of Safety Committee, L. R. Palmer, the National Safety Council was launched in 1912, and we all know how big and wonderful this movement of safety has grown throughout the United States.

The Association is much indebted for its success to the wise counsel and splendid guidance of John F. Kelly, the Managing Director. Through his personal efforts, we are, today, in as prosperous a condition as any other technical society in the country. I would not feel that this paper was complete, if submitted without some mention of his name.

In the near future, I hope to see our Association erect an Engineering Building here in the center of the Iron and Steel Industry, as a monument to its ideals.

I hope that the Association of Iron and Steel Electrical Engineers, as it passes along from one year to another will acquire an increasing realization of its duty, not only in furthering the growth of the use of electricity in the Iron and Steel Industry, but that it will also be successful in the attainment of the highest professional standing and usefulness to its allied industries.

▲

By W. T. SNYDER
President of the A. I. & S. E. E.—1916

The papers and discussion presented at the meetings and recorded in the proceedings of the year 1916 were the same subjects again recorded in the last, as well as in the intervening annual proceedings; Generation and Transmission of Power, Use of Central Station Power, Main Roll Drives, Motors and Control for Auxiliaries, Cranes, Portable Tools, Standardization, Safety, Apprenticeship and Education.

The later year books record additional subjects; Electric Welding, Combustion, Lubrication, Anti-friction Bearings, District Section Activities; all of it informative and a valuable reference.

After nine years of vigorous activity and growth up to 1916, the Association had reached the stage where some remodeling was necessary for continued progress. District sections were established, first in Philadelphia, then in Chicago, and later in Cleveland and Birmingham. A salaried Manager was installed, sustained partially by contributions from the Steel Industry.

Financial transactions for the year were $6,820, total membership 454. The latest year book (1930) records a business totaling $159,524, and the membership has grown to 2,100 participants.

Remarkable as has been the expansion of the Association, the development of the art which it sponsors has kept pace. A record of the development, in detail, would be too voluminous to set down here. The Association is entitled to a share of the credit. A fertile field lies ahead awaiting further improvement.

▲

By F. D. EGAN
President of the A. I. & S. E. E.—1917

The Association of Iron & Steel Electrical Engineers celebrating the twenty-fifth anniversary of its founding with the current issue of the Iron and Steel Engineer may view in retrospect a period of healthy growth, expansion and development into an important factor and agent of real service in the iron and steel industry.

The organization has its inception at a meeting in 1907 of a dozen or more Engineers, pioneers in their field, who were invited to view an exposition of steel plant equipment at the plant of a local manufacturer of electrical apparatus. At this meeting it was proposed that the visiting engineers organize an association to promote their common interest and serve as a counsel or intermediate agent between the operating engineers and manufacturers. The meeting in 1907 may be considered as the first convention of the Association of Iron & Steel Electrical Engineers. The members of this organization met from time to time to exchange views and discuss progress in electrical developments and issued an annual publication of the proceedings of these meetings. The financial status of the organization at that time was very weak and steel plants were invited to subscribe one hundred dollars each to defray financial obligations.

In 1917 it was proposed to reorganize the Asso-

ciation. Steps were taken to strengthen its position as an operating organization through a centralized management of Association business by a paid secretary. This move imparted considerable impetus to the development of the Association. A new monthly publication know as Iron & Steel Engineer was issued in addition to the annual proceedings. The Engineer soon obtained wide circulation and became known nationally and internationally. Membership increased from a meager dozen courageous pioneers to an international body of progressive operators and engineers. The scope and influence of the association for progress and perfection became universal in the steel industry. The publication as a medium of advertising became a source of enlightenment for Engineers as well as a carrier of tidings of latest developments in apparatus among associated manufacturers.

In 1930 centralization of the Association management was further perfected and the office of paid secretary was converted into a Managing Director. Its present incumbent has developed the financial status of the Association on a balanced budget system with a built up sinking fund in bonds for reserve emergency, all in the hands of a prominent Trust Company acting as a trustee. Membership in the Association has been extended to include Chief Engineers, Combustion Engineers, Lubrication Engineers, Mechanical Engineers and Safety Engineers of steel plants who meet in their own local sections and discuss problems pertaining to their operation in the steel business.

The Iron & Steel Engineer as the mouth piece of the Association performs a three fold function. It serves as a medium for presentation and circulation of up-to-the-minute technical data and papers on operating problems. Its possibilities as an advertising agent for manufacturers of apparatus associated with the Iron & Steel Industry are far reaching in as much as circulation of the publication is world wide as well as national. Participants in the advertising phase of the publication are assured that the story of their apparatus is accurately placed before operating Superintendents and Engineers who are specifying equipment for new projects and rehabilitation of existing production units.

The bound annual proceedings, a collection of the monthly publications, forms a convenient and reliable reference for Superintendents and Engineers in the solution of their operating problems.

Under centralized management the annual get-to-gether has developed from a local gathering of a few operating Superintendents in a single manufacturing plant, into a national convention, patronized by rank and file of operating Engineers and Executives from all over the country together with progressive manufacturers of associated apparatus. The Iron & Steel Convention of modern times exhibits all phases of modern steel plant equipment and occupies thousands of feet of floor space.

The Association has made great strides in progress throughout the twenty-five years intervening the conception and formation of its nucleus in 1907. Its healthy growth and expansion can be attributed to the foresight and effort of a centralized management together with the co-operation of a progressive and active membership.

It may be hoped in the continued activities of the Association in the next twenty-five years that it will surpass all previous achievements and maintain its place in front among the leaders in the "Parade of Progress" and expand its endeavor to encompass universal development in the steel industry and extend its clientele to include a still greater active membership. In this scope it will serve as a solid foundation for progress—accepting, developing, and perfecting, fundamentals of true progress and discouraging false principles and ideas hindering industrial development in the steel trade.

▲

By BARTON R. SHOVER
President of the A. I. & S. E. E.—1911-12

The years 1911-12 saw a number of important changes introduced by the Association which largely account for its present excellent position.

During the first five years of its existence the Association was almost a secret society, having on December 31, 1911, fifty-five members in good standing, all heads of steel works electrical departments. At the 1911 Annual Convention the more progressive members succeeded in having the Constitution revised, greatly broadening the requirements for membership and creating the grades of Honorary and Associate membership.

The wisdom of this change was proved by the fact that on December 31, 1912, the Association could boast of one Honorary member, Alva C. Dinkey, seventy-three members and one hundred and fifty Associates, a total membership of two hundred and twenty-four. The financial results were equally gratifying. The balance in the treasury increased from $508.19 on January 1, 1912, to $1,910 on December 31 of that year.

The revised Constitution also changed the term of the officers incumbency from immediately after the annual election to the following calendar year, thus allowing them to conduct the annual meeting for whose success they had labored for the previous nine months.

On June 19, 1912, the Association was incorporated, thus relieving the members from personal financial liability. The success of the 1912 Convention was largely due to the activities of the various standing committees, notably of the Safety Committee under the Chairmanship of L. R. Palmer. This Committee brought into being the National Co-operative Safety Council. Because the Association had sponsored the organization of the Safety Council it felt obligated to publish and distribute the first Proceedings. The cost of this action was so far beyond its financial resources, that the Association was forced to ask assistance from all of the Steel Companies represented by its membership, and to the credit of the industry, but one Steel Company refused, while quite a number donated more than the amounts requested.

The period 1911-12 was an important one to the Association, for during that time was laid the foundation upon which succeeding officers have built one of this country's most active Engineering organizations.

▲

By F. O. SCHNURE
President of the A. I. & S. E. E.—1930-31

In this George Washington bicentennial year we are privileged to contemplate another anniversary, the quarter century milestone of our Association. Just as

Washington was a pioneer in early American progress and statesmanship, so the Association and its Founders have pioneered in the early application of electrical equipment to iron and steel machinery.

The founding of this Association in 1907, under the same exacting business conditions as are prevalent on this, its twenty-fifth anniversary, was a challenge for co-operation. The demands were manifold, the data meager, why not then utilize the experience and judgment of all, to build the electrical practices that we now know have contributed so much to the growth of our gigantic industry.

Those who have gauged the performance of the early projects fostered by our Association and used them as divining rods for our present day problems, can appreciate the value of the Association of Iron and Steel Electrical Engineers to the individual, the company and the industry.

May we find, as the years roll by, our Association growing in strength and value as the memory of the "First American" continues to serve as an ideal.

▲

By O. R. JONES
President of the A. I. & S. E. E.—1915

Back in 1907 I was one of the twenty-eight men to receive an invitation from an electrical equipment manufacturer to visit their plant to inspect some new apparatus they had designed to put on the market.

At this gathering James Farrington suggested that we start a permanent organization for the mutual benefit of all operating Electrical Engineers, to exchange ideas in regard to our electrical work. The Association to be known as A. I. & S. E. E. Some time later we decided to have a pin to be worn by our members. This was left to Dr. Wheeler, who designed the present pin, made up of channels, angles and Z-bars, which represented steel products.

At the Convention held in Cleveland in 1914, I was elected President of the Association. Our 1915 meeting was held in Detroit, but owing to ill health and a serious accident at our plant (The Sharon Steel Hoop Company) I was unable to attend the Convention. This was the first meeting I had missed since the organization.

In the early days we had some very interesting and rousing good meetings at Pittsburgh, it being the only section at that time. In the last twenty-five years we have expanded and added other sections and branches of Engineering employed in the manufacture of steel.

Our members are not only in the United States, but we have members in several foreign countries. I am surely proud of the progress our Association has made in the last twenty-five years and hope we will continue on with the good work.

▲

By R. B. GERHARDT
President of the A. I. & S. E. E.—1923

It has been my great privilege and pleasure to have been a member of the Association of Iron and Steel Electrical Engineers for some nineteen years, during which time I have seen its activities and accomplishments grow to the point where now our Society occupies a position most unique in Steel and Engineering circles. The aggressive work of our officers and members and more particularly that of our Managing Director, together with the helpful co-operation of the Industry, has made this accomplishment possible.

On this, the occasion of the twenty-fifth anniversary of our existence, I think it most fitting that we pay proper tribute and respect to the energy and foresightedness of our founders, who laid the foundation work upon which has been built a great national fraternity.

▲

By JOHN C. REED
President of the A. I. & S. E. E.—1908-09

The Steel Industry of the world is to be congratulated upon the progress which it has made in the application of electricity to the production of iron and steel during the life of this organization which is now twenty-five years old.

The Association started out in a small way and was composed originally of an energetic group of electrical superintendents from a few of the leading steel plants. It has grown so as to comprise all branches of engineering as applied to steel.

The organization has lent its facilities to give impetus to any engineering efforts which gave promise of assisting in rendering the production of steel more economically.

During my administration, the first Safety Committee was appointed in 1908, under the Chairmanship of L. R. Palmer, and from the activities of this committee a national organization was formed within three years, the benefits of which have been felt throughout the length and breadth of the land.

There are many other activities in which the Association has been useful and the Association has every reason to feel proud of its record.

▲

By B. W. GILSON
President of the A. I. & S. E. E.—1920

In the panorama of electrical progress, we face the east and every rising sun for the last twenty-five years has witnessed a new electrical development.

From a crude unwieldy state, electrical equipment of all denominations has been refined and improved well toward the goal of perfection.

Credit is due the electrical manufacturers and the customer's electrical engineers for the rapid step in this progress and only shoulder to shoulder efforts have accomplished what has been attained in this past quarter of a century.

The successful continued advancement entirely depends on this united interchange of problems and their solution between builder and user, with no boundary as a limit to the greatest of accomplishments.

Our organization (A. I. & S. E. E.) more so than any other has had an unceasing fight to keep pace with the advance of the electrical science, and to date, has been more than successful.

▲

By C. W. PARKHURST
President of the A. I. & S. E. E.—1913

One of the things which all of the old timers in our Association will recall with the greatest satisfaction is the fact that in 1912 and 1913 the Safety movement became a real living force not only in the steel

and iron industry but in railroads and in fact all industry in America.

Lew R. Palmer was the Chairman of our very active Safety Committee. Safety First became a very popular slogan. With the backing of our Association our committee reached out to government officials and to the heads of all of the large industries to form the National Council for Industrial Safety. The name was later changed to The National Safety Council and it has become one of the great humanitarian forces of our country.

▲

By J. FARRINGTON
President of the A. I. & S. E. E.—1907-08

In 1907 an electrical equipment manufacturer invited several of the iron and steel mill electrical men to inspect a new line of steel mill electrical equipment and some of us conceived the idea of forming an association of the electrical men in the Iron and Steel Industry.

We, accordingly, held a meeting and organized, with the idea of meeting once a year to discuss our various problems. None of us at that meeting thought the Association of Iron and Steel Electrical Engineers would grow to the size, activity and prominence that it now has attained in twenty-five years.

The esteem and respect with which the Association is held by all steel men, from the Executives down to the Foremen is due, to a large extent, to the three following causes:

First—Membership and activities are confined strictly to the Iron and Steel Industry and their affiliations.

Second—Free discussions, welcomed suggestions and help given to solve the various problems confronting the Steel Mill Engineers.

Third—The co-operation, assistance and untiring energy given by the various Steel Mill Equipment Manufacturers.

The Standardization Committee have brought about the standardization of electric cranes, electric motors and anti-friction bearings that have saved many thousands of dollars, both to the manufacturer and consumer.

"The Iron and Steel Engineer," the official publication of the Association, has the distinction of being the only publication wherein is listed each year all the major installations of electrical equipment in the Iron and Steel Industry and where all of its papers and discussions pertain to the design, application, installation and maintenance of electrical, combustion, mechanical, lubrication and safety equipment and their accessories.

▲

By S. S. WALES
President of the A. I. & S. E. E.—1927

During my term as President of the Association of Iron and Steel Electrical Engineers our Country was enjoying a remarkable prosperity, being carried along on a wave of construction work which had been halted arbitrarily during the war period and retarded commercially by the excessive rise in prices immediately following. Under those conditions a successful operation of the Association's affairs could scarcely be avoided.

The valuation placed on securities in 1928 and 1929 was only the crest of this wave and the crash was only the breaking of this superficial crest of the wave. What we are suffering from now is the natural back wash of the underlying wave, the reaction of industry exhausted by unprecedented productive activity. The length and severity of the present depression are undoubtedly accentuated by the general low tide in the business of the whole world.

In 1873, 1893, 1908, 1914 and 1921 we had severe depressions, during some of which the same fears for the ultimate recovery were expressed, almost in the same words as we hear today, but good times came back and the lean years were forgotten in the plenty of prosperity. This will again happen, the danger being in this forgetting of the troubles of the past and not preparing for the natural fluctuations and not guarding against aggravated fluctuations in values in the future.

While our Association is a Technical Society from which no financial profit is derived by the officers or members, still it is organized and run as a business and will require clear vision and sound judgment from, and places great responsibility upon the present officers and directors to successfully "carry on" during this period of business inactivity.

Our Association has assumed a very enviable place in the technical world and it is the ambition of our Managing Director, supported by the officers and the Board, to make the A. I. & S. E. E. a most important influence in the steel industry second only to the American Iron and Steel Institute.

Through the vehicle of our publication, The Iron and Steel Engineer, which embraces the Association's Proceedings, we have laid before us each month the most important advances in steel manufacture and material handling, new electrical, mechanical, combustion, lubrication and safety applications, improvements in repairs and upkeep, fresh from the minds of those whose business in life is to deal with these special problems.

Our advertisers realize the value of the Iron and Steel Engineer as a means of communication with the Industry and are supporting us loyally.

Our annual exposition of new developments and progress in Steel Mill Equipment will be held as usual, this year in Pittsburgh, and has been encouraged by the Manufacturers in spite of the severe business depression we are experiencing. It should be attended by all who can arrange the time, as it is equal to many special trips to the works of the Companies represented.

Let all our members pull together to give our officers assistance and encouragement in this trying period by their loyalty and support.

▲

By F. W. CRAMER
President of the A. I. & S. E. E.—1929-30

In reviewing the twenty-five years of existence that our Association has enjoyed, many ideas suggest themselves that are worthy of comment. One of the most prominent of these is the personalities that make up our membership and their present attitude toward the organization. It has been my privilege during the past twelve years to become acquainted with a great majority of the steel mill electrical engineers and to hear from them their own story of what the Association has accomplished.

(Continued on Page 194)

The Design of Industrial Equipment In Welded Steel

Presented before Philadelphia Section, Association of Iron and Steel Electrical Engineers, December, 1931.

By EVERETT CHAPMAN
Director of Engineering and Research, Lukenweld, Inc., Coatesville, Pa.

The purpose of this paper is to outline present methods of welded construction and especially the work Lukenweld, Inc., is doing, from the standpoint of having you know about our problems and to crystallize the methods by which we have obtained our results.

We are engaged in the fabrication of structures to be used in industrial equipment. By that I mean machine tools, mill equipment, punch presses, etc. The welding profession has now reached the point where they can make a weld that will stick two members

EVERETT CHAPMAN

together despite the fact it may get wet, and at a price which is commercially usable.

In any commercial process, if you get four bad results out of a hundred attempts, it is still in the art stage; but if the process is predictable in the ratio of one bad piece out of a thousand, it is ready to use commercially. Welding has advanced to the place where the normal expectancy of making a defective weld is so low that it is commercially usable. It can now be called a production tool.

The cost of a structure is entirely dependent on the maximum stress that exists in it. The first cost of a structure such as a punch press that will last two years is not comparable with one that will last twenty years. Total expense or cost per year over the term of useful life bears a direct relation to the maximum stress that exists in a structure. Before examining the question of maximum stress in a structure let us discuss design criteria of three classes of structures: bridges, first of all. You do not care how much a bridge sags when a truck goes over it: All you care about is that the bridge is designed in such a way that it does not fall into the river. So the design is based on the ultimate strength of the material. You do not care if one of the tension eye-bars in the bottom of the bridge has to stretch a little to redistribute the load. In fact such a job is not satisfactory until the parts have adjusted themselves to the whole by stretching a little; but you do not want a punch press to do that.

The next subdivision of equipment is the steel fishing rod. There your criterion for maximum stress values is the yield point. You do not care how much this fishing rod sags, but you do not want it to take a permanent set as did parts of the bridge. This design criteria necessitates the use of more material for a given load, but this is still not the way to design a punch press.

Referring to the third class of equipment, in which punch presses fall, the only question which arises is: How stiff is it? Will it hold the working parts in proper alignment? Is it stiffer than the part which was previously used? This deflection requirement is the most difficult of all to meet. Stresses have to do with deflection only when taken in conjunction with the size of the structure.

Let us consider another thought at this point. Stress distribution, in the complicated types of structure we have to deal with, is a fairly indeterminate thing if approached by our usual design methods. The trouble with the usual engineering formulas is that they are handed to us as a sort of mathematical ten commandments, and no attention is paid to the assumptions from which these conclusions were derived. We assume neutral axes where there are no such things. The results mean nothing and that is why we have factors of safety. You may figure a 3,000 lbs. per square inch average stress, but there is very probably some point in the structure where you have 30,000 lbs. per square inch, and this point is the only one in which you are interested from the viewpoint of how long will it last.

One job was submitted to us in which the stress ratio was 12-1 based on the old accepted design. Through redesign this stress ratio was reduced to the proportion of 3 to 1 before it was considered advisable to build it.

A typical example of the non-uniform strength which may occur due to inattention to such insignificant things as dovetails and holes, is illustrated in Fig. 1. This shows a celluloid model of the design as submitted to us of a large mill housing for rolling sheets. These housings are now made in cast steel and report has it that some 600 of them fail every year. The failure always shows clean metal and while this is somewhat puzzling, the conclusion that generally is drawn, is, that the housing itself is not strong enough. The dovetails which are cut upon the interior of the sides are merely for the purpose of holding the chuck brasses which form the journals in which the rolls revolve. The photo-elastic analysis shows some twenty-

four places for incipient cracks which may start at any time, especially as the load imposed upon these housings is one of severe impact. Impact is particularly dangerous inasmuch as the magnitude of the stresses under impact loading is extremely indeterminate but in addition to that the fact that the load is repeated many times a day makes the service decidedly one of fatigue. The cutting of the dovetails into this rather nice homogeneous rigid frame utterly ruins this member as far as strength is concerned under a fatigue service.

Fig. 2 shows the same housing with the knobs which were produced by cutting the dovetails, removed. This has considerably less metal in it than Fig. 1, and yet the structure is perhaps a dozen times as strong under its applied load, in this case severe impact and fatigue. This particular point continually arises with reference to the stress distribution within any given structure. Removal of metal very often produces a stronger structure than the one which we had before. As for producing a means to hold the brasses, it is an easy matter to make these dovetails without recreating the notches. One of the proposals at the present time is to put a three inch liner around the interior of this

FIG. 1—Photo Elastic Model of Conventional Design of Mill Housing.

housing in such a manner as to not bring back the notch effect, this being easily effected by welding straps on the side of the frame.

Let us now proceed to give some consideration to the proper welding design viewpoint. I mean by that, the design viewpoint which the engineer must entertain when attacking a given problem for execution in welded steel. The thing that will appeal most to the engineer about welded steel construction, when once he is under way, is, the pleasure he will enjoy in being able to put metal where he has never been able to put it before, and in those forms which he, as an engineer, knows to be most desirable.

Fig. 3 is a notable example of a straight side punch press executed in welded steel and following more or less the conventional design, using tie-rods in conjunction with a crown piece, a bed piece and two columns. The advantages of this particular press over one constructed to conventional design is that the substitution of the superior material, steel, has resulted in a stiffer press. May I point out at this time, however,

FIG. 2—Photo Elastic Model of Mill Housing after Redesign.

that duplication of these old designs implies that we will also inherit most of their troubles, and a press executed in welded steel exactly as we would make it in cast iron, carries along with it all the inherent limitations which the same design had before. Would it not be expedient at the time of the redesign of a frame from castings to weldings to reconsider it as a structure and find out if we cannot produce a better structure to suit the given load conditions, keeping in mind that the old practices of casting and riveting decidedly influenced the shapes of structures which we formerly produced. The thought suggested to you is that just around the corner may be a structure which is eminently more suitable for resisting a certain set of loads than anything which has hitherto been used.

Let us examine the one-piece press shown in Fig. 4 in which there are no tie-rods. It is conceivable that tie-rods cannot be eliminated in every case, because in

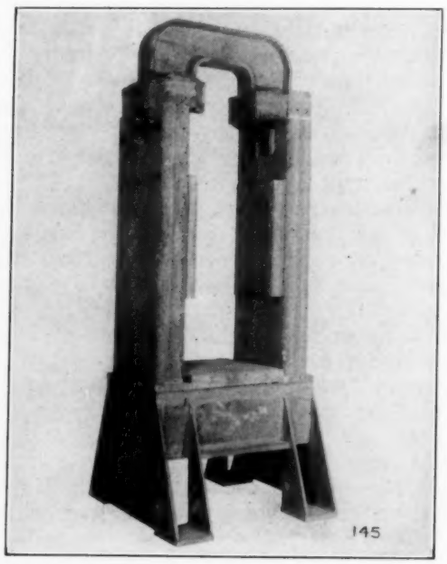

FIG. 3—Conventional Design for Punch Press.

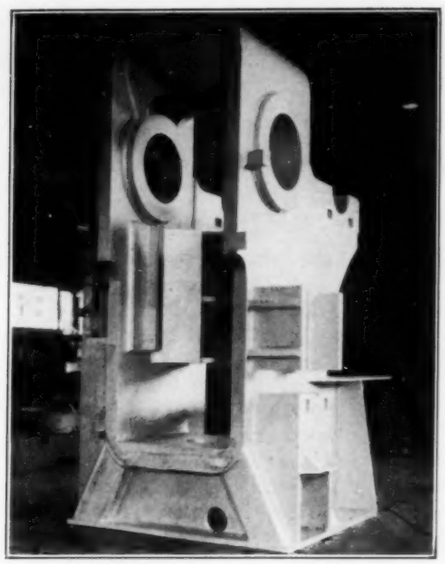

FIG. 4—Improved Forging Press Design.

many shops the machining equipment is so small that the pieces have to be machined in separate parts. Very often the presses are so large that they cannot be shipped in one piece and they must be knocked down. Fig. 4, illustrates a 500-ton forging press executed in welded steel with complete freedom of design. This frame weighs 43,000 lbs. and is about 13'0" high. There are few points of similarity between this press and the press that preceeded it. Machining costs of this one-piece press are considerably less than they would be if the same frame was divided into four parts. This press frame machined on a post mill was taken off completely finished in three set-ups.

However, there are many more points to be noted than merely the machining possibilities. The body of the frame is made up of 4½" plates, four feet wide, bent around to form two shallow legged U's. These were welded together top and bottom to form a one-piece structure, with the plates around the bottom and sides applied at the point of greatest bending moment. These plates in conjunction with the floor plate form an admirable box section at the point where the stresses are the greatest. In addition, these plates form on one side a mounting for the trimming shear, and on the other side they afford a convenient mounting for the outboard bearing bracket. The crown has been built into the frame which gives a much stiffer construction than is ordinarily achieved and it will be noted that the frame is strutted apart in the middle to prevent side breathing under the action of the load. The bending of such heavy frame members as these is an economical thing to do. In the first place, we achieve a degree of appearance at the rounded corners. We have cut our heavy 4½" welding in half and in addition we have taken the stress concentrations out of the corners where they are very likely to occur. The plate which functions for the purpose of restoring the die space lost at this radius has not been welded around the radius. It has been plug welded at several points over its surface to produce the proper bearing area. The welding and engineering professions at the present time do not realize the amount or extent of savings which can be effected in constructing a press of this sort from welded steel plate. Savings have been made all down the line—Freight savings—quick delivery—Machining savings—flexibility of design—complete engineering freedom together with a mighty heavy sales appeal.

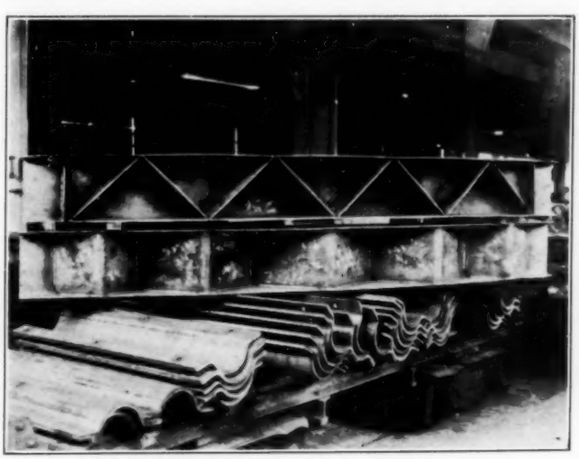

FIG. 5—Experimental Crane Girders Diagonal Diaphragms.

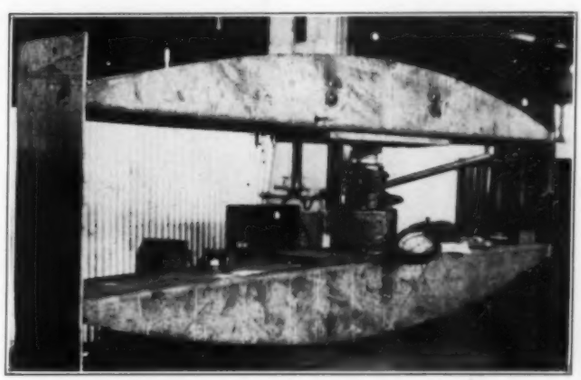

FIG. 6—Static Test on Experimental Crane Girders.

Another example of the wide latitude which is enjoyed by the engineer when he delves into this welded steel picture is illustrated by the results shown in Fig. 5. When the problem of welded crane girders was put up to our Engineering Department the question which presented itself was how we could place our diaphragming material in such a manner so as to gain additional beam strength. Diaphragms are usually placed inside the closed box section for the purpose of stiffening the compression members inasmuch as these members are unstable and liable to buckle. This metal is absolutely useless as far as beam strength is concerned and as such is merely secondary material. If we can use this same material in such a manner as to contribute to the beam strength, we have made forward strides in the utilization of our steel. It was thought that if we latticed the plate members to produce a series of triangular prisms, it might be possible to achieve some definite results along this line.

Fig. 5 shows the bottom view, before the tension flange was applied, of a pair of experimental girders 11'0" long which were built up to test out these theories. The upper girder represents a zigzag latticing of

FIG. 7—Typical Crane Girder Installation.

plates, placed in such a manner as to act as a third web member, while in the bottom girder the plates are zigzagged up and down when looking at the side so as to simulate a modified Warren truss.

Fig. 6 shows these experimental girders bucked up against one another to determine the relative merits of the two methods of diaphragming. The load was applied to the girders through the medium of a hydraulic jack and strain gauges were used to thoroughly explore both the compression and tension members of these beams. In the course of the test it was found that the compression member was working at a considerably higher stress than the tension members. This was not at all obvious at first glance inasmuch as theory calls for a box section to have equivalent stresses in the top and bottom. The explanation of this discrepancy will be given later. To sum up the result of this test, these girders showed an increased strength over a box section of the equivalent section modulus of about 38%. We have a girder here which can be built at about 10% less weight than the equivalent riveted girder, and which will show a strength increase of about 38%. This was subsequently demonstrated by taking the unbroken beam of this pair and matching it up against a riveted girder. The riveted girder failed in the compression member while some of the rivets along the tension flange started to shear.

With reference to the dissimilarity in the stresses in the top and bottom flange, it finally occurred to the engineers running the experiment that the bottom tension flange on these girders was in the form of a curve. This is an apt illustration of the troubles which a designer may get into by religiously following theories which have no basis in fact. Theory says that we can make a girder of constant strength by making its profile parabolic. In other words, as the bending moments decrease toward the end, we are able to cut out some of the metal and keep the stresses constant. It, therefore, behooves us in order to save weight on girders to cut them out according to the parabolic law which theory calls for. This, however, results in a curved tension member, and the strain gauges discovered the fact that the tension member was not doing any work at all while the compression member was rapidly approaching failure. The tension member had to straighten out between chord points before it could go to work.

FIG. 9—Bridge Ends for 10-ton Crane.

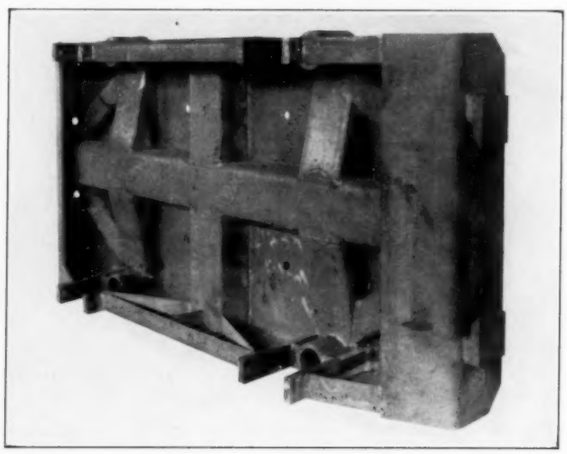

FIG. 10—Underside of Welded Open Hearth Charging Car.

Fig. 7 illustrates a pair of girders which have been corrected in this respect and which embody the criss cross zigzagging of plates on the inside. It will be noticed that the profile of these crane girders is trapezoidal starting from constant moment of inertia at middle section and tapering off toward the end. Inside

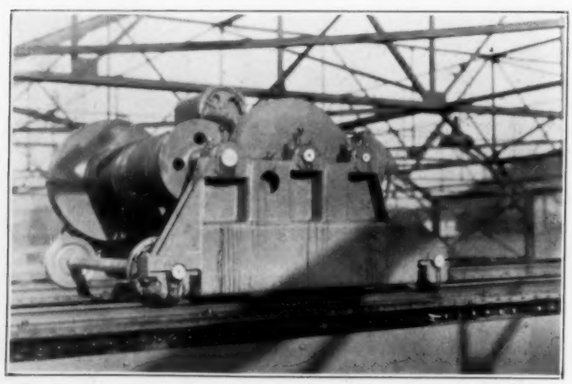

FIG. 8—Crane Trolley of Welded Construction.

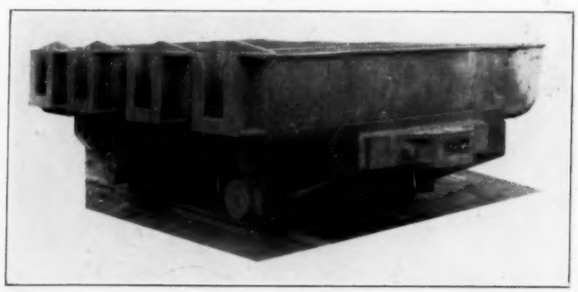

FIG. 11—Open Hearth Charging Buggy and Boxes—Completely Welded.

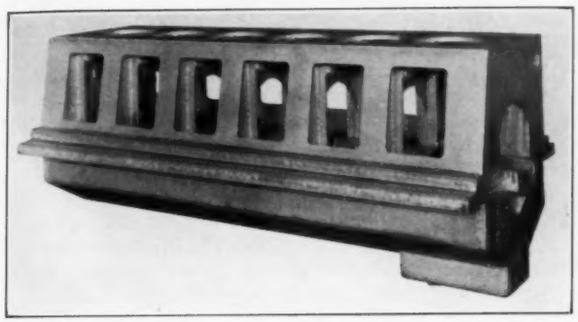

FIG. 12—Diesel Engine Block.

of these girders are two straight plates at the point where the tension member changes direction. This is very important. These 40'0" girders illustrated in Fig. 7 were designed for a working load of ten tons. Before they were put in use, however, they were bucked against each other with a hydraulic jack in between and a load of 30 tons was applied to each beam, equivalent to a load of 60 tons on the crane. The fibre stress at this load was 28,000 lbs. per square inch, yet these beams are considerably lighter than the equivalent beam which would be used in the old form of con-

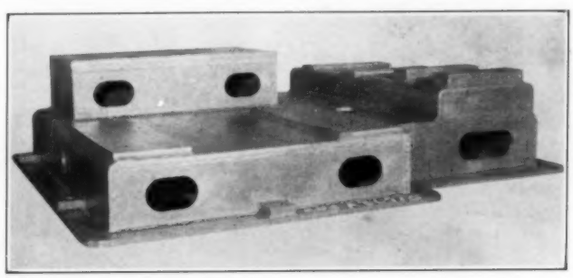

FIG. 13—Welded Base for Large Tube Mill Drive.

struction. Among other things, a crane is a transportation unit which takes power to start and stop it. It also takes time to speed it up and to stop it. It certainly means more than economy of first cost to have less weight in a crane of this type.

Fig. 8 shows a welded crane trolley and the use of

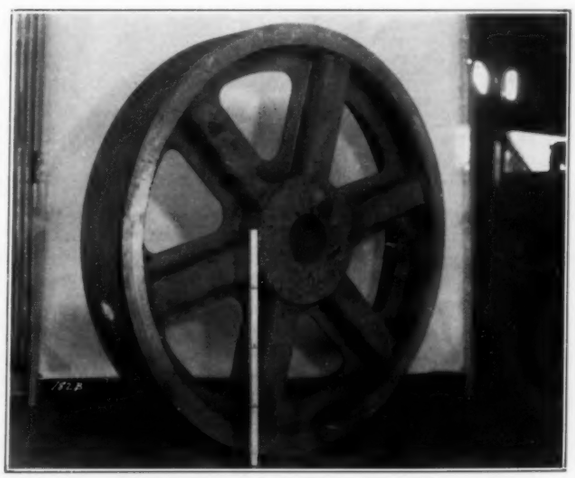

FIG. 14—9,000 Lb. Gear Blank.

FIG. 15—Illustration of Gear Rim Weld Showing Method for Laying out Teeth.

bent sections is exemplified. Crane trolleys such as this were formerly made in three pieces; cast steel ends, and a cross girth which was machined, fitted, and rivetted to these two steel castings. It is impractical to cast a complete crane trolley in one piece because they present a rather spidery casting problem, yet it is most feasible to weld them in one piece, and this is what was done in this particular case. This possibility not only does away with the machining, fitting, and fastening the girth to the end castings, but it also results in a more rigid job, one which will stay rigid after ten years in service, one whose bearing alignment will be definitely preserved.

Fig. 9 shows a welded end truck which has been constructed along the lines suggested by the crane girders previously shown. With the lattice plates zigzagging up and down as they do in the illustration, we were able to place the girders themselves at one of the panel points of the inclined plates on the inside. This results in an extremely strong and stiff construction. It has been demonstrated that a welded end frame of this sort will cost in the neighborhood of two thirds that of a steel casting, leaving out pattern items.

Fig. 10 illustrates a charging box buggy which has recently been constructed and put in service at the Lukens Steel Co. Through the use of the square tubular box section as illustrated in the underside photo Fig. 10, we have been able to re-

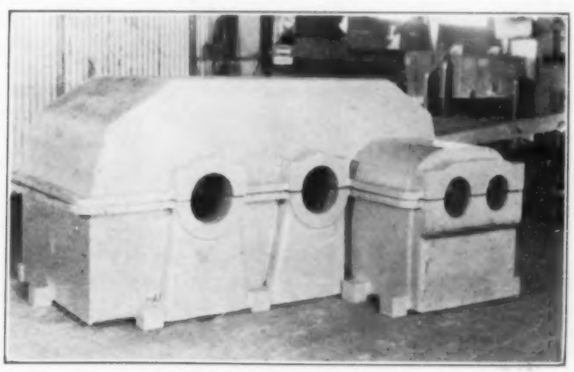

FIG. 16—Gear Case for Bending Rolls.

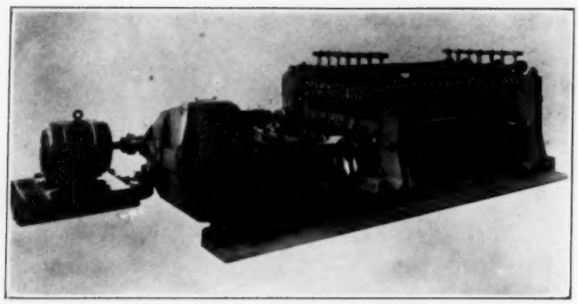

FIG. 17—Large Roller Leveler.

duce the weight of this particular buggy approximately 50%. It is a perfectly feasible and practical thing to use thin metal sections provided we take care of not only the main beam strengths, but also to properly care for the secondary stresses. The large tube down the center of this body provides the requisite train strength while the small side members and the trusses into the spring nests produce the requisite rigidity for carrying the distributed load.

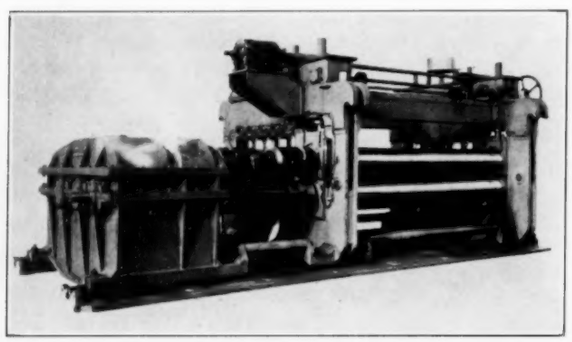

FIG. 18—Large Roller Leveler for Straightening 1" x 144" Aluminum Alloy Plates.

Fix. 11 shows the completed buggy with four welded steel charging boxes on top. These are a saving in weight of two tons on the buggy, and 500 lbs. each on the welded steel boxes against the equipment which was formerly used. This is a net saving in weight of three tons per unit. A train of ten cars running around the yard of steel mill in this construction weighs 30 tons less than the equivalent train in cast construction. Assuming that the charging floor of the average open hearth is about 30' 0" from the ground, the saving in terms of the coal pile can be readily computed. In this most important field: transportation welded steel has wide applications.

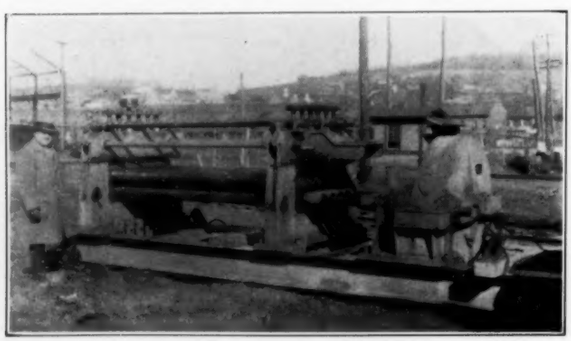

FIG. 19—Light Roller Leveler.

Steel is the best structural material known to mankind, not only for strength but also for rigidity and with that for a start, it is a matter of proper design procedure to produce the lightest possible constructions for given rigidity and strength. In this connection Fig. 12 shows a small Diesel engine block which was constructed sometime ago. The greatest single drawback to the wide acceptance which the Diesel engine must eventually command is due to its extreme weight, and especially in Marine work does this become important. In Fig. 12 we have an engine block which has shown a considerable reduction in weight over any materia! which was previously used; and understand that this saving in weight has not been done at the expense of rigidity and strength.

Fig. 13 illustrates a heavy type of base construction which was used in an electric tube mill drive and serves to illustrate the admirable adaptability of this class of work on single one piece jobs that

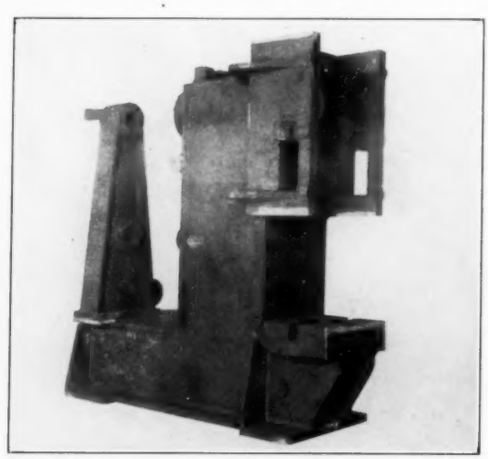

FIG. 20—Housing for 525 Ton Washer Press.

are in an experimental stage. This base weighs about 5,000 lbs. and was manufactured without a pattern, merely from blueprints; the delivery time on this particular job being eight days.

Now let us examine the construction of some heavy welded gears. Fig. 14 illustrates a 9,000 lb. gear in which the rim is made of .40 to .50 carbon steel, while the web, spokes and hub are made of a lower carbon steel. The web is a single disc; the hubs are large gas cut doughnuts welded on the outside of the web, while the face of the gear is bucked up by the channel shaped arms which are welded on each side of the web. The rim is rolled out of a single strip and Fig. 15 shows the manner in which the rim weld is made. It is essential to keep the weld metal out of the teeth, not that it is not strong enough, but with a carbon content in the weld metal of only .08, the weld metal does not present as good wearing characteristics as that of the .40 to .50 carbon steel which constitutes the remainder of the rim. It is our practice, therefore, to scarf this rim from the inside up to a point above the root of the tooth and do this welding from the inside. We leave the crack on the outside as shown in Fig. 15 in order that the indexing of the teeth

may start at the proper point. This results in teeth of homogeneous carbon content while the low carbon weld metal is kept below the pitch line where it is not subjected to any wear.

Fig. 16 illustrates a type of gear case used on a large bending roll. All the large bearing blocks in this case are cut from plates of various thickness. The ribs under each bearing are formed of box sections which are bent on a taper. These sections afford considerable stability when their sides are run into the hold-down bolts on the bottom, and a very pleasing construction results. It should be noted at this point that many things are possible with welded steel which would not ordinarily be thought of by the engineer considering cast construction because he knows before he starts that some very desirable constructions will cost too much.

Fig. 17 illustrates a large finished machine, a roller leveler which has been in use for some two years.

Fig. 18 illustrates an even larger roller-leveler which is now in service at the U. S. Aluminum

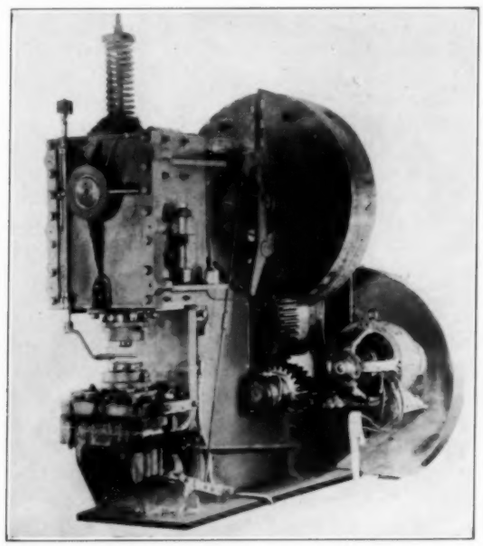

FIG. 21—Same as Fig. 20—Completed Press.

Company. This complete leveler weights 248,000 lbs. and it is desirous to call attention to the harmonious appearance presented by welded steel construction when the whole machine is completely welded.

Fig. 19 illustrates still another roller-leveler of a light type. This particular leveler does not represent the heaviest and most economical type of welded construction, yet in this case, by the use of welded construction, a reduction in the purchase price of 11% was possible. This 11% applies to the complete finished price and not to the parts of the castings involved.

Fig. 20 illustrates the welded viewpoint as executed in a large 525 ton washer press. It will be noted that the tension flange which is a 4" plate has been bent to form the top of the platen in order to relieve the stress concentration which occurs at these points. The box section which was used in this particular case has much thinner webs than the casting which was formerly used while

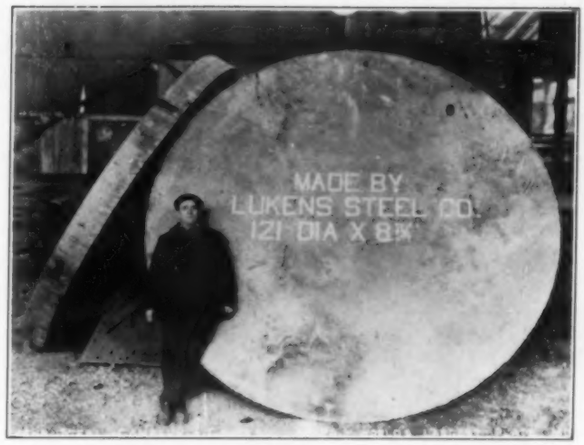

FIG. 22—Flywheel Blank 121" Diameter.

the metal has been placed front and back in the flanges where it will do the most good. This particular redesign involved a weight saving of 5,000

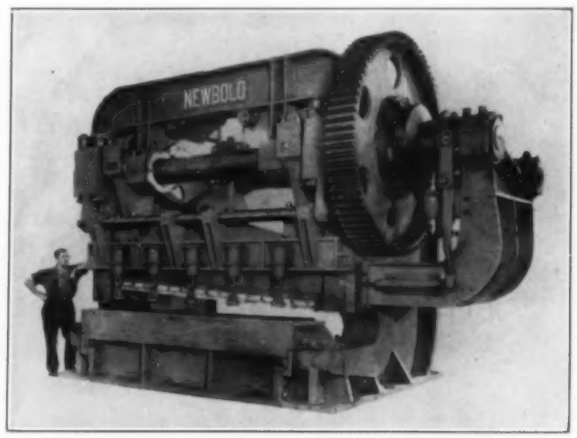

FIG. 23—Large Shear—Shearing plate 1¼" x 120".

lbs. over the cast steel frame formerly considered. It is merely a matter of juggling the proper design factors in order to effect weight saving such as

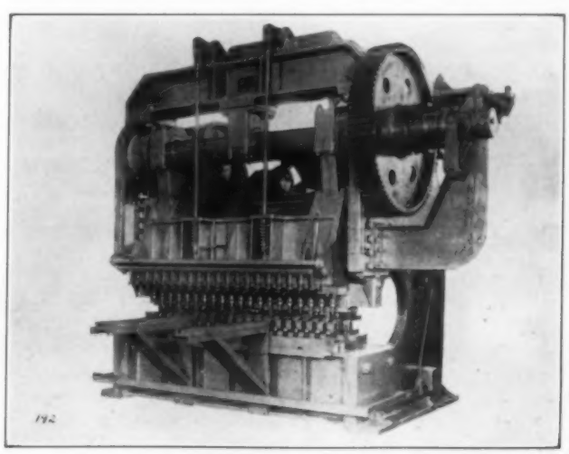

FIG. 24—Heavy Punch Press.

illustrated here without sacrificing strength or rigidity.

Fig. 21 illustrates this completed machine in which the gear train and flywheel were made of steel. With a steel flywheel we are able to achieve a safe rim speed of about 12,000 feet per minute as against 6,000 feet per minute in the old cast iron type. This will make savings not so much in the wheel itself as it will effect the type of motor, size of shaft, and size of the bearings that are used. Doubling the speed of a certain fixed horse power motor reduces its cost to one half. Such a simple substitution as this may result in a considerable saving throughout the whole power transmission if the proper attention is paid to the logical conclusions to which it leads.

Fig. 22 illustrates some of the larger disc flywheels which can be procured at Lukenweld, Inc. A solid homogeneous silicon killed steel makes an excellent flywheel even in the form of a disc although this does not represent the most economical metal distribution. However, for a mill drive, the type of flywheel illustrated in Fig. 22 cannot be improved upon at a commercial price.

Figures 23 and 24 illustrate some additional types of heavy mill equipment which are available. The only castings in Fig. 23 are the small air cylinders on the hold-down. This shear has been in severe service for the last three years and will shear up to 1¼" thick by 120" wide. It is worth while to know that the shear knives on this shear do not have to be sharpened as often as the knives on the previous cast machine. This is due to additional rigidity and the consequent alignment which this frame possesses under load. The large multiple press illustrated in Fig. 24 is a good example of the heavy type of punch shop equipment which can be cheaply and quickly fabricated from welded steel.

Fig. 25 illustrates a bending roll recently fabricated and now in use and which has a capacity of 8" thick by 50" wide. It is worth while to note that the spreading action on the two bottom rolls, some 1,000,000 lbs. due to the pull down, is resisted in this particular case by a 3" plate. However, it is not reasonable and logical to penalize the rest of the bending roll with that 3" plate and, therefore, outside of the section which carries the main stresses a ¾" plate is used. This can be seen on the end of Fig. 25 where the 3" plate tapers down into the worm box and bears against the bronze collar which supports the worm gear.

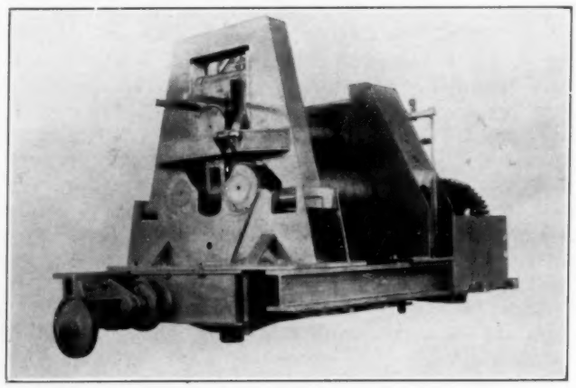

FIG. 25—Bending Roll for Plate 8" Thick x 50" Wide.

It is worth while to note in this picture that considerable contour relief has been afforded in the face of the 3" plate holding the two bottom rolls. The continuous and repeated spreading action is very likely to cause a major failure at this point if proper contour considerations are not taken into account.

It would be impossible to entirely cover in one single paper the many and varied uses to which welded steel construction lends itself, and so I have chosen my subject matter from the vast field of mill machinery in the fond hope that I may have emphasized just how close to home the electric arc is casting its rays.

Discussion

Discussed by

F. O. Schnure, Electrical Superintendent, Bethlehem Steel Company, Sparrows Point, Md.
E. Chapman, Director of Engineering and Research, Lukenweld, Inc., Coatesville, Pa.
J. C. Reed, Electrical Engineer, Bethlehem Steel Company, Steelton, Pa.
H. P. Clever, Superintendent, J. C. Brill Co., Philadelphia, Pa.
L. F. Coffin, General Master Mechanic, Bethlehem Steel Company, Sparrows Point, Md.
N. C. Bye, Chief Engineer, Henry Disston & Sons, Inc., Tacony, Philadelphia, Pa.
W. N. Horko, Electrical Engineer, Henry Disston & Sons, Inc., Tacony, Philadelphia, Pa.
A. H. Yoch, Philadelphia, Pa.
W. J. Diederich, The Autocar Company, Ardmore, Pa.

F. O. Schnure: I am sure we all cordially thank Mr. Chapman for his instructive and interesting talk.

I would like to ask Mr. Chapman, what would you consider the proper contour for a crane girder?

E. Chapman: A Trapezoidal profile tapering down from the ends to the straight middle section, so that the tension member is shaped as you would shape a violin string over two bridges. (See Fig. 7).

J. C. Reed: This paper tonight has been very comprehensive, very instructive, very enlightening. I did not know that welding had been used quite that extensively, notwithstanding the fact I have been somewhat active in the welding shop, trying to learn something about it. The field of design, of course, is one which is new. What we need to do is obtain the confidence of designers. The designing investigations which Mr. Chapman has carried out, I am sure we are all thankful for.

H. P. Clever: I listened with a great deal of interest to the talk this evening. It brings up a question which is paramount at the present time. The aluminum companies are making great strides toward saving in weight. Have you done

anything in car structures, and in what parts do you feel there is an application for steel versus aluminum? Do you feel there is a chance to save over aluminum, or would you prefer the aluminum section?

E. Chapman: Let us take, for instance, the side frame of a car. What is your design criteria? Do you care how much it sags?

H. P. Clever: We do to a certain extent, certainly. I mean by that the sagging depends almost entirely on the live load that goes into the body. We would like to have it more rigid.

E. Chapman: Do you put the metal in from a strength standpoint or from a deflection standpoint?

H. P. Clever: Deflection.

E. Chapman: Then you can save money and weight. I am thinking of closed box sections for combined stresses. In steel the box section for an equivalent rigidity can be made lighter than aluminum.

H. P. Clever: When you take the figured stress, do you figure in the non-homogeneity of the weld? Do you use the same stress you would use in the center of a plate? Do you count these different from the straight sections?

E. Chapman: In the first place, there should not be pin holes in the weld and it should be homogeneous; in the second place, unknown strains can be taken out. Supposing we had to use a material with which we could stick steel plates together perfectly satisfactorily but the material only had 11,000 lbs. per square inch endurance instead of 22,000 lbs. per square inch. What we have to do is to design for that physical value. In other words, here is known material with known characteristics. It is merely a question of defining the stress service requirements of the job and defining how much of the material to use.

In practical terms, we find the endurance limit on commercial weld metal about 22,000 lbs. per square inch, about equal to the plate. It is merely a matter of obtaining known values and designing to them. You could make a joint with molten glass which would resist a fatigue loading. The point is you must know how much glass to use and what the stresses are at the contours.

We thoroughly believe in paste covered electrodes. We consider them worth while, but we pay for it in that we cannot weld overhead.

In a welded building the joints are either rigid or they are broken. There is no such thing as a serviceable semi-rigid welded joint. These rigid joints combined with the naturally abrupt changes of contour which you have in a framed structure raise a lot of questions in my mind for which I have no answer at the present time.

L. F. Coffin: I believe I understood you to say you annealed all welds. Is that true?

E. Chapman: Yes.

L. F. Coffin: Another comment I would like to make. It is rather surprising to see so many flanged sections used in these welded structures. It would appear that so many flanged sections would be rather expensive.

E. Chapman: A press brake is a very inexpensive machine to use. A bend in ⅜" plate costs about 40c to make.

L. F. Coffin: That might be true on a large number of pieces but how about on a separate piece of machinery?

E. Chapman: We do not find it so. The point is, you save so much on welding that the procedure is most economical.

N. C. Bye: What is the strength characteristic of cast iron? Don't you run into difficulties in getting a good joint?

E. Chapman: I do not think cast iron welds can be made successfully. When I referred to the incorporation of castings, I was talking about cast steel. In cast iron the arc weld is as brittle as glass and for the very sound metallurgical reason that the quick cooling leaves what was formerly free carbon, in the combined state; a white cast iron.

W. N. Horko: I would like to ask what kind of gas you use for gas cutting.

E. Chapman: Acetylene.

W. N. Horko: Have you done anything with illuminating gas?

E. Chapman: We have tried gasoline. I think General Electric has gone over to illuminating gas entirely, up at Schenectady. I do not know what characteristics are obtained with illuminating gas, although I understand it is successful.

A Member: May I inject something here? Some years ago there was an opposition between operating with acetylene and illuminating gas and the results were the cost of illuminating gas was such they went back to acetylene again.

E. Chapman: I do not know anything about relative economies involved in the use of these different gases. Illuminating gas can be had very inexpensively, but there are other factors involved.

A Member: I would like to ask Mr. Chapman if he took two flat plates he was going to weld, would he put those two together or clean up first? I am talking of an incipient crack.

E. Chapman: Gas cut edges should not be used raw at a critical change of contour. They should be ground.

A Member: Was that done in the picture shown us?

E. Chapman: That was not a crack, it was a gouge, due to the flicking of the flame. We do not get cracking on low carbon steel. Our gas cutting superintendent reports that he cannot find any cracks under the microscope on even .40 carbon steel. In that gas cut frame I showed you it was an actual gouge, due to change in pressure, the presence of a minute inclusion or any one of a number of things.

Experience will show that where you have critical sections it is much better to incorporate a large radius in that corner and then grind. When the torch is changing direction it may falter from mechanical deficiencies and this is a source of gouging. Of course, the whole burden of this argument is to keep away from sharp corners. It is an old argument, but you would be surprised to see how many pieces of equipment have these intentional, or accidental cracks in them. This whole welding picture would be sunk if we did not have cutting torches, but we must use all of our facilities intelligently.

A. H. Yoch: You were speaking of using a

paste covered wire and always annealing your welds. I am rather interested in knowing what temperature that is done at. I am also interested in knowing whether you found a difference with your bare wire. It has been my experience it was difficult to anneal a weld, I was wondering whether a weld made with a bare wire would anneal and stand fatigue as well as the paste covered wire.

E. Chapman: Our results show the paste covered rod is desirable because it gives perfect results throughout a wide operating range. You can produce an excellent weld with bare wire within a very narrow range, but here is the danger; if you run the heat up to get penetration and fusion you produce oxidation, and your oxides cannot be removed by annealing.

A. H. Yoch: That is what I had in mind. The point I was making was: had you actually tried to anneal bare and covered wire welds.

E. Chapman: The brittleness occurring in the welded zone where the weld was produced by a paste covered wire is not the brittleness of the same kind made with bare wire. You must remember that even with paste covered rods, the annealing is not directed at the weld; the annealing is directed at the damage done to the parent metal, and to the relief of strains produced by welding independent of the type of rod used.

A. H. Yoch: Your annealing temperature has to be low to carry this out.

E. Chapman: No, higher — because strains come out at 1100°-F. and this temperature will not anneal. If the carbon is high you have to heat above critical temperatures. The only place we get into this .40 carbon is on large gears, on most all other equipment we keep down to .15 carbon, in which case the metallurgical damage is slight and we have merely the strains to contend with.

W. J. Diederich: There was one peculiar thing I noticed about that gear. I happen to be in automobile work. You show the weld coming up to your gear teeth. When they come out they come out at the base of the tooth.

E. Chapman: That isn't the point. The point is we do not keep that weld out of the teeth because of any question of strength, but below the pitch line because it does not have good wearing qualities. These gears have gone all over the country, and they have been very satisfactory. There would be no hesitancy on my part to use them for the most severe type of service.

W. J. Diederich: Our question is very similar. I see failures every once in a while that are due to the filing tool having a nick in it.

E. Chapman: You may have heard the story of the webs on gears which were used in some radial airplane engines. A perfectly beautiful job where the webs were thinned down to the last thousandth, then the inspector came along and stamped his initials half through the web. Fatigue failures occured in a few months. If you get the most minute pin hole in a highly stressed region, troubles are bound to follow.

▲

Magnetic Testing of Iron and Steel

By A. V. de FOREST
Magnetic Physicist, Welding Engineering and Research Corporation, New York, N. Y.

Presented before Philadelphia Section, Association of Iron and Steel Electrical Engineers, January, 1932.

▲

The progress of magnetic methods of test has been rather slower and steadier than the spectacular performance which was originally predicted by the enthusiasts. In spite of a great deal of careful scientific work and a good many commercial experiments, the actual method of test has not been very widely applied. In this way the use of the magnetic possibilities is somewhat akin to that of X-ray. Both have been in laboratory use and both have been well understood by the specialists but only within comparatively recent times have they been applied to what would be called commercial testing or inspection. In the cast of magnetic test methods, the difficulty has been largely the matter of relating magnetic phenomena with mechanical properties which in themselves are exceedingly indefinite and very difficult to measure. We have often been told that any change in the physical or chemical structure of steel will find its reflection in the magnetic properties. This is quite probably true but if the change is not appreciable in the physical properties and is appreciable in the magnetic we are left with an insoluble equation. It therefore appears that much painstaking work must be done on the difficult mechanical testing for impact and fatigue properties before the magnetic measurements can be correctly interpreted. Unfortunately it is very seldom that fatigue and impact results can be measured on finished product in a sufficient number of cases to give statistical numbers with which to operate.

A good example of the kind of work necessary for a full appreciation of magnetic testing lies in its application to ball bearing materials. In this case the steel itself is expensive and of high quality. The heat treatment is most carefully watched and tests of crushing strength and endurance are frequently made yet with all these factors carefully controlled, the actual variation in endurance may vary more than 50% between seemingly identical tests, and in every case an average of many tests, in some cases 50 or more, is needed to even indicate a relationship between heat treatment and endurance of a particular lot of steel. It is quite probable that the difficulty is caused by the random distribution of the most highly stressed or most defective point at which the fatigue failure gets its start. Any test for structure or general internal stress condition such as magnetic analysis gives, could not be expected to predict fatigue failure except in the case of statistical aver-

ages. In certain cases where this has been done results are excellent but the amount of work involved is enormous and seems all the more so in these days of low production.

The correlation of magnetic tests with impact is far more simple. The mechanical test is more direct and where it can be applied to a finished product, the results are decisive.

FIG. 1—Magnetic Tester for Weed Tire Chain.

At the American Chain Co., magnetic testing has been used for more than ten years to control carburizing treatment of both carbon and alloy steel chains. In this case a single magnetic measurement is made which is empirically adjusted to run parallel with impact value. To a certain extent this is self-adjusting in that a certain impact value can be met by a comparatively deep and comparatively soft case or by a comparatively thin and comparatively hard case. The magnetic factors run very closely parallel with the hardness and depth of case and good results can be obtained over the commercial range. The apparatus for this use has been repeatedly described in the literature and was exhibited at the A. S. T. M. Exhibit in 1931. Briefly, an alternating current bridge is used in which the permeability and the eddy current loss can be measured or at least indicated independently. A measurement of each can be made or a measurement combining the two effects in any proportion. The magnetizing force involved can also be varied so that a fairly wide range of magnetic phenomena can be covered. It is well known from the work of Sanford at the Bureau of Standards and others that internal stress conditions are most marked at low values of the magnetizing force, while conditions of grain size and composition effect the saturation. In this alternating current test an average value is obtained for the magnetizing cycle but this average can be taken over a cycle of low magnetizing force or one of large magnetizing force and different effects obtained for different applications.

A later development of the testing art was published in 1928. In this case an oscillograph was used to follow the magnetic changes throughout the whole cycle of magnetization. It was expected that the wave forms would be modified by various factors such as grain structure, size, internal stress and composition in characteristic ways. In some cases this is true and the method is very valuable as a study of the magnetic effect of the many variables in solid steel. The oscillograph method is in use by the Magnetic Analysis Corporation for uniformity inspection of bar stock, wire, etc. I have applied it commercially for heat treated forgings and experimentally on many problems including heat treated wire and razor blade materials but in general have found a galvanometer method more commercially applicable.

A photograph is shown of a recording mechanism for continuous inspection of razor strip. In this case a reflecting galvanometer is used tracing a path on a piece of bromide paper at such a rate that approximately 3,000 feet of strip form a record 3" long. If any individual inch of this length is defective the record will so indicate and commercially this spot may be cut out or if the defects are sufficiently numerous the whole strip may be retreated. The history of this equipment illustrates a very general condition. It was installed when there was much difficulty with variations in razor blade stock. Hard and soft spots were encountered at intervals which came and went without warning. Before the equipment had been working three days the source of the difficulty was located in the hardening operation and in a very few minutes was remedied. After this there was no further difficulty for a period of many months when suddenly a new disturbance came in, this time in the steel itself. Thanks to the continuous inspection, however, it was quickly discovered and readily corrected. At present there is no difficulty but it is worth while maintaining the inspection so that when the inevitable trouble comes up we will be ready to catch it at once.

Magnetic methods of test are far more than methods of inspection and rejection purely and simply. They find their greatest usefulness in assisting the intelligent application of already existing metallurgical knowledge. The magnetic properties like the physical properties of a piece of steel as tested

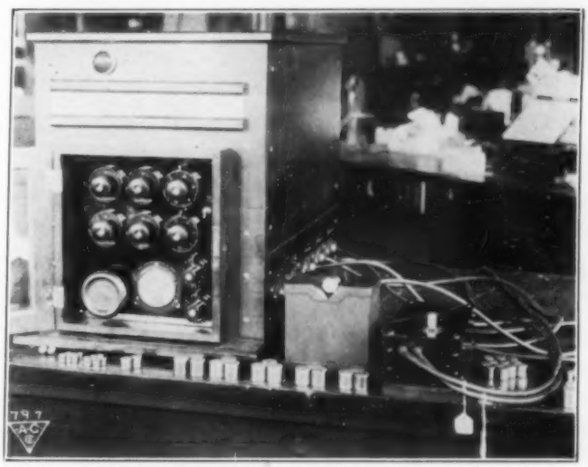

FIG. 2—Magnetic Test for Balls and Rollers.

in bulk as in static tension machines are purely a question of average values. On the other hand, fatigue properties and to an extent impact values involve an exceedingly small volume of material. For this reason an exceedingly local defect may cause failure to an otherwise perfect structure and it cannot be expected that a test of the entire volume will show a defect existing over a single element of its

length. For instance a wire a mile long may break due to a defect a tenth of .001" in extent. In this case we most obviously must know at what point to apply the magnetic or any other test to investigate the source of difficulty. Following along this train of thought we come to a magnetic defect test purely and simply and in this case there is none of the difficulty of interpretation, there is no complication with structure and mechanical properties and we have a method of seeking actual physical discontinuities in iron and steel materials.

The use of finely divided iron powder or filings for the purpose of discovering minute and invisible cracks was promoted by Major William Hoke during the days of high production and bad steel in the late war. Major Hoke found that many of the high carbon steel disks intended for gauge manufacture were defective and that the defects could easily be located by holding the blank on a magnetic chuck and flowing over it oil or kerosene in which finely divided iron was held in suspension. The method has frequently been used in that form and in many cases quite successfully. Other possibilities and applications of the method were, however, not studied until much later and this very effective method of test has been singularly little used.

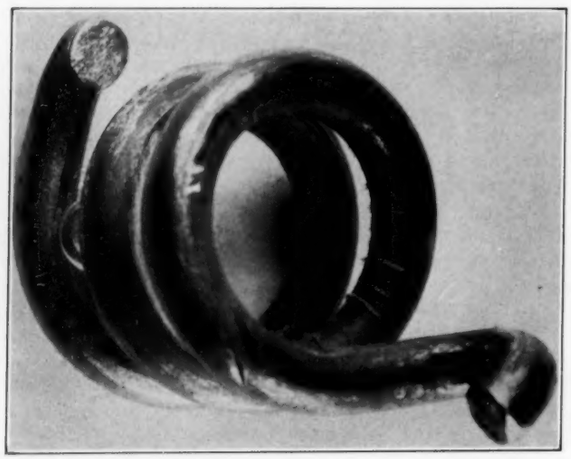

FIG. 3—Fatigue Cracks in Spring Showing Tensile Overloads.

In 1929 in the course of applying the method to seamless tubing, a thorough study was made by the writer of the proper methods of magnetization and application of the finely divided iron particles. As a result, the Magnaflux method was developed and arrangements effected for controlling the Hoke patent and subsequent applications.

For many purposes, a dry method rather than a liquid flotation of the dust is desirable. For this use, particles are prepared in which the shape of the iron is long and thin rather than spherical or roughly cubical lumps. It can readily be seen that the same weight of particle when in the form of a rod is magnetically much more effective than a sphere. In fact a rod of ten diameters long is roughly fifty times more effective than a sphere of the same weight.

On examination of ordinary prepared iron powder or dust as manufactured by commercial processes, there appeared a very undesirable quantity of roughly spherical particles. Our first care was then to secure the proper shape and size of iron particles. These must also be of very low carbon free from alloys and relatively high permeability. These magnetic properties are secured by thorough decarbonization and reduction in hydrogen. Proper precautions must be taken to prevent the resulting powder from taking fire on exposure to air. To prevent this and also for other purposes, the iron particles are insulated from each other by a non-magnetic coating which may be either white or black. This coating also acts as a lubricant to prevent packing of the finely divided iron chips and to break up the polarization due to metallic contact between the iron particles. In the case of some individual applications all these precautions are not needed but in certain others they are essential to success.

In regard to the method of magnetization the usual scheme has been to use an external magnet or electro magnetic yoke to supply the proper field. It was soon determined that for many purposes this resulted in polar effects due to the method of magnetization which interferred with exploration by means of the iron dust. The desirable condition requires that there should be external poles and, therefore, no attraction of the iron dust except at the point of discontinuity caused by the defect in question. In many cases this can be accomplished by magnetizing the part with a current flowing through the material to be tested, and this current may be either direct or indirect in character.

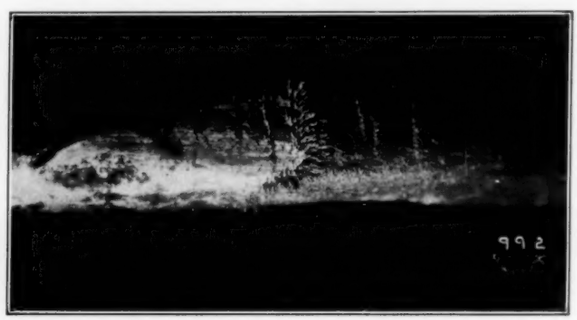

FIG. 4—At 20 Magnification. Fatigue Cracks in Hardened Spot on Rope Wire.

The successful use of Magnaflux inspection requires a thorough knowledge of the metallurgical, magnetic and in some cases mechanical features of the product. Many problems of inspection can be solved or greatly assisted by the method but in other cases the system is not applicable. In the first place it is restricted in general to cracks and discontinuities at or immediately below the surface. The application of the method to weld inspection, particularly to arc welding, has been successfully used in certain cases where blow holes, lack of fusion and defects beneath the surface have existed. Application to this field, however, requires special study—see for instance the various publications by Mr. Watts of the Westinghouse Company dealing with this matter. Journal American Welding Society September, 1930.

The Magnaflux method may be used in two different ways: in one case for the examination of a finished manufactured article to be absolutely sure that there are no defects of the nature of seams or the like in the steel and that no forging, heating,

quenching or grinding cracks have been introduced in the course of manufacture. Another use of the method consists in locating invisible fatigue cracks which have developed after the material was put in service. No test as applied to the finished article will foretell the development of fatigue failures in use. In very many cases, however, the development of the fatigue crack is slow. Knowing this, many parts of engines, automotive equipment, aeroplanes, and railroad equipment are examined at more or less routine intervals. In this case the Magnaflux method simply allows the eye to detect at once the presence or absence of cracks. The difficulty of searching very carefully over large areas is thus avoided and a positive answer can be given at once that there is no crack instead of the negative answer that a crack was not found; which is the only possible statement after a visual examination.

The Magnaflux method will discover cracks which are under internal compression and, therefore, will not absorb oil if tested with the oil and whiting method. In this type of inspection much time is usually lost by careful examination of grinding marks, and incidental scratches which appear on the surface. It is frequently very difficult to decide without repolishing whether or not these marks are significant. In the examination with Magnaflux, superficial marks are in general not indicated so that much time is saved through the ability to determine at once whether a scratch is or is not the starting point for a crack lying immediately below it.

In the case of wire, this property is especially useful. Die scratches which are unimportant from a strength standpoint can easily be distinguished from quenching cracks which frequently start from such a line, or from laps or seams in the original steel.

The photographs illustrate some of the types of defect found by this dust method. Figure 3 illustrates incipient fatigue cracks, the position and number of which are always highly significant. In this case these cracks appeared on the opposite side of the spring from that which would be normally expected. Furthermore, they were caused by tension and not by torsion, for in the latter case they would have been at the customary 45° angle to the axis. A redesign of the equipment is now in progress to relieve a secondary stress which played no part in the normal action of the machine.

Figure 4—Photo of a .050 wire illustrates exceedingly fine fatigue cracks starting from a bruised surface on a rope wire. The main break is visible to the eye but the small cracks on each side were not apparent until magnetic inspection was made. The lesson in this case is that heavy fatigue stresses are involved together with a surface hardened condition which only occurs in very rare instances.

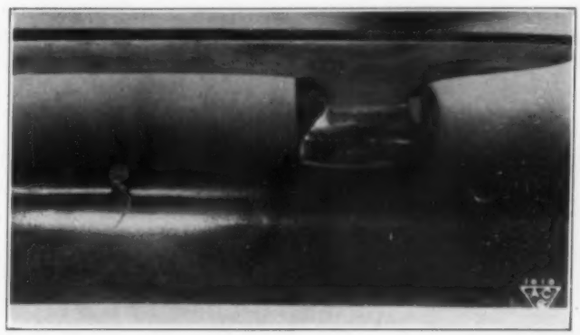

FIG. 5—Fatigue Crack in Turbine Blade. Forging Cracks in Skate.

Figure 5 illustrates forging cracks in a skate and a fatigue crack in a turbine blade. The method has found a very promising application in periodic examination for fatigue cracks and a very important lesson can be learned from the observation of these incipient defects.

In the vast majority of cases failure is caused not by the general properties of the metal involved but by a local defect which the dust would have located ahead of time or by a radical defect in design with the possible addition of accidental overloads. In the case of automotive equipment it would appear as though fully 90% of the trouble lay in the design and infinitesimal amount in the selection or heat treatment of the material involved. As a metallurgist, this was a distinct shock for in common with many of my profession I had hoped to remedy most of the troubles of the world by the development of better and stronger steel. I now feel that this is an unimportant part of the general problem. Proper design comes first and next defect free materials. After that come materials which in themselves are stronger and more resistant to fatigue conditions.

Discussion

Discussed by

F. O. Schnure, Electrical Superintendent, Bethlehem Steel Company, Sparrows Point, Md.

A. V. de Forest, Magnetic Physicist, Welding Engineering and Research Corporation, New York, N. Y.

C. L. Lane, Metallurgist, Florence Pipe Foundry & Machine Co., Florence, N. J.

K. M. Raynor, Electrical Superintendent, Bethlehem Steel Company, Bethlehem, Pa.

B. J. Wilson, Leeds & Northrup Company, Philadelphia, Pa.

W. N. Horko, Electrical Engineer, Henry Disston & Sons, Inc., Tacony, Philadelphia, Pa.

W. A. Smiley, Research Engineer, Bethlehem Steel Company, Steelton, Pa.

Dr. G. S. von Heydekampf, Research Engineer, Baldwin-Southwark Corporation, Philadelphia, Pa.

Lieut. A. Willink, Ordnance Dept., U. S. Army, Frankford Arsenal, Bridesburg, Philadelphia, Pa.

G. R. Toon, Leeds & Northrup Company, Philadelphia, Pa.

E. Spring, Metallurgist, Henry Disston & Sons, Inc., Tacony, Philadelphia, Pa.

J. Miller, W. Wharton Company, Easton, Pa.

F. B. Foley, Superintendent Research Department, The Midvale Company, Nicetown, Philadelphia, Pa.

D. A. Lawless, Naval Aircraft Factory, Navy Yard, Philadelphia, Pa.

F. O. Schnure: I enjoyed Mr. de Forest's talk very much. There is a question I would like to ask him. Of course everyone in the manufacture of steel is interested in methods of testing that steel.

I would like to know if this method could be applied to rails, wire rod or pipe, continuously, and if so, how fast and how hot?

A. V. de Forest: That sounds like some order. Hot steel is not magnetic, so that we are out when we are above the critical point.

As far as the rail and the heavy steel sections are concerned, I do not know anybody who has gone into them. There are so many elements in that type of material—the rate of cooling, size of the grain structure, the carbon, manganese content—all of those things would be reflected in these magnetic properties. And yet the price of the rail is so low you can not readily replace rejections.

As a matter of fact, I have not studied the problem, but have been very much interested in it. In talking with some of the people who have gone into this matter, I have learned that they have had plenty of trouble.

I am very sure it would be exceedingly difficult to test the material before heat treatment and predict what it is going to do after heat treatment. It is very much like inspecting a baby three years old and say what he is going to do at the age of thirty.

F. O. Schnure: You do not think, then, for example, in a 4" pipe, that you could detect flaws in the wall?

A. V. de Forest: No, sir; not with this method of magnetic analysis. The Magnaflux test has worked pretty well on welds. The Westinghouse Company has done quite a lot with it on material containing heavy welds. Mr. Watts, of the Research Department, is quite enthusiastic on the use of this method on material up to ¾". The results from applying this test vary with the quality of the weld and also the material out of which the weld is made. In defects below the surface, you have to know your stuff quite a little to get along with it well, but in thin material like pipe it is doing a good job. In fact we have no hesitation in stating that this system used in testing thin products such as pipe, has given very satisfactory results.

The Committee on Non-Destructive Testing of the American Institute of Mining and Metallurgy of which I happen to be Chairman, is interested in all the different types of weld examination and tests, and we have a program underway in which we make quite elaborate investigations to follow up the different kinds of welds used commercially to determine the different defects and what methods to use in tackling them. I do not know of any foolproof manner doing this work.

C. L. Lane: I would like to ask Mr. de Forest if this test has been used on cast iron.

A. V. de Forest: Not that I know of.

C. L. Lane: Could it be applied?

A. V. de Forest: I think it could very well, but I have never applied it on cast iron, neither do I know anybody who has.

K. M. Raynor: I have just a question or two I would like to ask Mr. de Forest, have means been devised to determine non-magnetic inclusion in steel? Also, what depth of penetration is possible?

A. V. de Forest: We can get readings related to cleanliness in hardened steels, but they are faint as compared to variations from other causes.

As to the depth, theoretically there is no particular limit; using direct circuit magnetization one could get right down through a heavy section, but using 60 cycle A.C. current the depth of penetration is something in the neighborhood of ⅝" or ¾", so that 60 cycle is ruled out. We can get down perhaps 1" or 1½" quite successfully, but the answer you get is very difficult to calibrate or get any idea of non-metallic as compared with the other things we get in steel such as the hardness, grain size, etc. The rate of cooling is an important element.

K. M. Raynor: Is it true that polished steels are much more easy for your magnetic determinations than for steel having a little coating of rust, and to what extent?

A. V. de Forest: Rust would not bother you.

B. J. Wilson: I would like to know the effect of regularity—say to cam shafts?

A. V. de Forest: Well, that is all right if they are all the same shape. If you are running one shape, and then another, you have to set up for each individual section. As to running cam shafts that is all right. The shaft does not bother you if they are all the same shape.

W. Horko: Just yesterday I saw a piece of steel which was accidently broken. Upon examination we found something that looked like a globular shaped piece of slag about ¼" in diameter. I was wondering if that defect could have been detected with this method of testing before the steel was made into a part of the machine.

A. V. de Forest: How far below the surface was this thing?

W. Horko: It was at the middle of the cross section which was about ¼"x1¼".

A. V. de Forest: I think the Sperry conductivity test would have made the better job of it than this method. That is almost a magnetic test, and would be better than this test for a deep seated defect.

W. A. Smiley: I have listened with considerable pleasure to Mr. de Forest's remarks, and I believe that we as American citizens feel proud of his work for one of a number of reasons. The first reason I have in mind is that the most novel work done along this line has been performed by two Japanese and Honda. Then again we have a Swede that comes around and puts up a magnetic analysis on the outfit they use in the open hearth, which reads within a point or so. Mention has also been made as to what has been done in England, and I think it is altogether high time America had a look-in on this sort of business. I think you gentlemen will agree with me that any method of testing which has an output of one hundred separate pieces a minute which must be handled deserves considerable merit. Mr. de Forest mentioned one rail test. There are many others. So much for the history of the thing and my appreciation of Mr. de Forest's remarks.

There is just one question I had in mind. You have mentioned the matter of stress. We all know that the amount of stress in a piece of steel has ever been a stumbling block in our path. I have just been wondering, in the test of the sections in which you have worked, whether that had ever appeared as a complimentary or rather as a blanking out measure that would subdue defects due to

change of composition, and whether the stress located up in the piece has ever been known to give values?

A. V. de Forest: Absolutely yes; the stresses located in the steel have made it impracticable, to say the least, as far as I know, to get any results on certain materials. I have worked with wire for a long time, and hope that we will some day be able to use magnetic methods on wire, but it looks like a very long chase to untangle the stress from the structure.

Dr. G. S. von Heydekampf: Mr. de Forest's talk was very interesting to me, as Baldwin Southwark Corporation about four years ago started manufacturing testing equipment which in some way is competitive with the magnetic test. We are mostly building equipment for destructive tests but are vitally interested in new non-destructive methods such as Mr. de Forest's magnetic inspection of steel. We are glad to have had the opportunity to cooperate with him in similar respects.

Mr. de Forest mentioned hysteresis in a magnetic test. We have studied mechanical hysteresis in stress and strain which seems to run parallel to electromagnetic hysteresis. This matter however is too involved that I could dwell on it at this time. I only wanted to mention the fact that there is another connection between certain important but little known mechanical properties and the magnetic properties. I think Mr. de Forest will sooner or later be able to give valuable information on this quite recently discovered correlation.

A. Willink: In the manufacture of artillery ammunition it has been the practice heretofore to break the bar in an attempt to find any defects such as pipes that may occur in the bar. The pieces were then put in the hydraulic press and forgings made. In recent years the horizontal forging machine has come into the picture. With that machine the forging comes out in four operations and is not cut from the bar until the forging is completed. In order to have the same feeling of security in this new method, it is imperative to have some-non-destructive means of detecting pipes in the bar stock.

Do you know of any non-destructive means, Mr. de Forest, by which that could be done?

A. V. de Forest: I wish I did. I do not know. It looks like quite a job. Perhaps some bright chap has got the answer already, or some bright chap will hatch it out. With this magnetic analysis test you have a pretty slim chance of finding pipe. Occasionally you will find it where it sticks out like a sore thumb; then again it is difficult to catch. I have worked with it for some time, in small sizes, and I know it is difficult, but quite possibly it is a thing that can be done simply if a fellow has ideas enough.

G. R. Toon: I looked up this matter of magnetic analysis some time ago, although I never had any actual experience with it. I have read a number of papers on the subject, and recall one experiment with a number of drills which were heat-treated at different temperatures but the composition of the drills was slightly different. These drills were then tested for hardness and also underwent a magnetic analysis. These drills were then used and some were found to be good and some not good.

A. V. de Forest: That is one of the things some people overlook when they are investigating this matter. That the heat-treatment on different specimens is different, the quenches and composition are different, and you cannot expect to get the whole answer from a simple magnetic test. The mechanical tests showed that different thermal treatment was needed for drills cutting different materials, and no magnetic test could be expected to correlate with all cutting tests.

G. R. Toon: I would like to ask Mr. de Forest if that is still true, that each problem has to be studied itself in order to determine the best magnetic analysis?

A. V. de Forest: Yes, that is perfectly true. That drill test was the most complete investigation in the history of magnetic analysis, and was the work of quite a number of individuals. It brings out very well indeed this exact point, that there is no criterion to determine the best mechanical properties and each individual case has to be treated of its own merits.

G. R. Toon: I want to amplify Mr. de Forest's answer, if I may. The magnetic analysis in its final form has been carried to the nth degree. Honda can take a piece of steel, and after putting it through his machine, really give you the chemical analysis of that piece and tell you what heat-treatment it went through. This is a very closely guarded national secret, and all we know about it is that results have been achieved along certain lines. We know it can be done because it has been done.

A. V. de Forest: Similar claims have also been made in this country.

E. Spring: I have been playing with powder back here and got quite a lot of amusement out of it.

I want to thank Mr. de Forest for what he has told us. I can see several applications for this magnetic analysis in tool steel.

I have noting else to contribute except my appreciation to Mr. de Forest for his interesting talk on this subject.

A. V. de Forest: I would like to remark that I have had some experience with Disston steel. Magnetic tests were made on saw blades of different heat treatment, to prove that the test would pick out the bad ones. When, however, cutting tests were made, all the saw blades were perfect, so that magnetic testing lost a job!

E. Spring: It is not only in connection with hack-saws that I think the greater part of the work can be done. There are many other uses for this magnetic test.

J. Miller: There is one subject that Mr. de Forest has not touched on tonight. The question I allude to is the testing of seamless tubing. I understand the process used is an ordinary coil put around the tube, and the tube painted with wax. I would like to know if he paints the whole tube.

A. V. de Forest: That isn't magnetic testing, that is purely an electrical device. But it might be interesting to the audience to know about it. It was a scheme for testing wall thickness, pure and simple, in a piece of tubing that could only be gotten at from one side. The method is simply to generate current in the wall and measure temperature reached. The tube may be coated with paraffin.

The melting point gives an isothermal line which represents the wall thickness.

F. B. Foley: I am sorry I was not here for the start of Mr. de Forest's talk, but, in the discussion that ensued, the thought struck me there are some very subtle differences in steels that might easily be confused with other variations that occur which would effect magnetic or other tests. It is possible to have in one bar of steel the same chemical analysis and the same physical properties throughout, yet, by a very small difference in heat treatment, one piece from the bar will show twice the impact resistance value that another piece will. Now I can imagine that such a difference as this may easily be apparent on such a device as the magnetic tester, and the difference attributed to something else, some chemical or physical heterogeneity.

A. V. de Forest: That temper-brittleness phenomenon shows up very readily in the magnetic test.

F. B. Foley: Is it possible, when this phenomenon is present, to confuse it with something else?

A. V. de Forest: That is possible; it is the easiest thing in the world. You have got to find out in each individual case, but after finding it out you can easily distinguish whether the specimen has been heat treated properly. It is very much the same way with the tool steels that run into a graphitic state. There is no change at all in the hardness.

F. B. Foley: This phenomena is not particularly uncommon. The difference in the two pieces of steel is simply that, after both have been quenched to harden, the one has been quenched in water after drawing and the other air cooled. This difference between the rate of cooling and the drawing temperature is sufficient to cause a pronounced difference in the impact value of two pieces of steel.

D. A. Lawless: I would like to ask Mr. de Forest if it is possible to test specimens or materials of various diameters in this apparatus? I am thinking in particular of the practicability of adapting the apparatus to the testing of bolts of various sizes.

A. V. de Forest: It takes quite an elaborate calibration. One cannot go from one size to the next without alteration.

D. A. Lawless: I understand that some investigators in this work have used two solenoids in their apparatus. I would like to inquire if two solenoids are used in connection with the apparatus exhibited here?

A. V. de Forest: No, not for this particular bridge.

A. Willink: In making these shells I was speaking about, it is necessary to give them 100% hardness test. I was thinking of a possible application of this magnetic test to replace the hardness test. One of these shells tested there in the rough machine test is likely to vary anywhere up to .05 of an inch on a three inch diameter. Would the difference be greater than the variation of hardness?

A. V. de Forest: No. Practically speaking you could stand a variation of 1/8".

▲

Asbestos In Industrial Friction Materials

By J. W. HEMPHILL, JR.
General Power Products Department, Johns-Manville Sales Corporation, New York, N. Y.

▲

Presented before Pittsburgh Section, Association of Iron and Steel Electrical Engineers, January, 1932.

As the dropping of a stone in the middle of a pond sends ripples out in every direction, so that eventually every inch of the shore line has felt the influence of the act, so the coming of the gasoline and diesel engine into the field of industrial hoisting and conveying machinery made itself felt in the farthest reaches of machine design and construction. For these two forms of motive power brought with them the heavy-duty clutch and brake, and the demand for light weight, high-speed, high capacity equipment. These factors have presented many new friction problems to designer and manufacturer alike.

On shovels, locomotive cranes and similar equipment, the internal combustion engine, which is usually operated at full speed in order to develop the maximum power at the moment of greatest load, places a terrific strain on the clutch, which is let in against the full torque of the motor. The clutch is required to pick up the static load and bring it to full speed quickly without excessive jar or chatter. Space is at a premium, and the cry is for more speed. Higher temperatures automatically follow higher speeds, and clutches and brakes of a given size are required to do much more work than was formerly expected of them. Many equipment builders changed their friction surfaces from cast iron to cast or rolled steel in order to gain strength at reduced weight, only to find new aggravations confronting them.

Another instance of the effect of modernization upon the friction problem is seen in the brake problems that developed with the introduction of frictionless bearings in traveling cranes. Reduced friction in the moving parts meant greater inertia to be overcome by the friction materials (brakes).

The problems involved in producing a friction material which will not only meet these requirements, but will stand up under continued service, naturally divide themselves into the following phases. One, the adoption of the proper kind of base materials; two, the selection of the kind of metallic surface against which the friction material must work; and three, the determination of unit pressures, peripheral speeds and ways and means for the dis-

sipation of energy in the form of heat. A discussion of each of these factors follows:

Asbestos the Base Material

Asbestos is the base material from which all modern industrial friction materials are manufactured. The most obvious advantages of asbestos friction materials over wood, paper fibre, leather and other organic substances are its resistance to heat and to wear. As a result, a wide variety of friction materials have been developed around the asbestos base. These have made practically obsolete the old metal-to-metal friction drives. The lubrication between surfaces, which was needed to prevent galding and rapid wear of the metal, caused so low a coefficient of friction that heavy and cumbersome units were required. This is in direct opposition to the space requirements placed on the manufacturers.

J. W. HEMPHILL, JR.

The Characteristics of Asbestos

Asbestos is a fibrous crystalline substance occurring in many different forms and chemical compositions. What is commonly termed Serpentine or Chrysotile asbestos is the form used in the manufacture of friction materials. It is a calcium magnesium silicate containing on the average 14% of water of crystallization. Chrysotile asbestos can readily be spun into yarns and textiles and consequently lends itself admirably to the manufacture of many types of linings and friction materials. Contrary to the usual belief, asbestos is not a refractory, but simply a heat resisting material. Some of the water of crystallization is driven off at temperatures below 500° F. At 700° F. there is a decided loss in strength of the fibre. At temperatures of about 1200° F. asbestos is completely dehydrated, and the resultant material is a chalk-like substance having practically no mechanical strength. There is no known substance with the mechanical strength and fibrous structure of asbestos, which has an equal temperature resistance. Therefore, it can be readily understood why in order to have satisfactory friction material operation, it is necessary to keep drum temperature below 500° F. as a maximum.

Types of Friction Materials

Asbestos friction materials may be divided into two general classifications—the flexible or fabric types, and the rigid or moulded types. In the flexible class can be listed the folded and compressed or folded and stitched type of lining, and the various forms of woven linings.

Folded and Compressed or Folded and Stitched friction material is one of the oldest types of asbestos linings used in the industrial field. This material is made of asbestos cloth woven with inserted brass wire yarns, coated with a rubber compound, folded to required size, hydraulically pressed and vulcanized under pressure. Folded and Compressed friction materials are best suited for heavy duty, slow moving machinery, where there is not an excessive amount of heat. Under high temperatures excessive "fading" or a drop in coefficient of friction, will likely occur, with the possible separation of the plies of fabric due to the softening of the rubber binding compound. However, when applied under proper conditions, this type of lining has a lower wear-factor than any of the other types of flexible linings.

Woven Linings, as a class, are woven solid from brass wire-inserted yarns. They may be woven to size and calendered. They may be also woven oversize, pressed or die-formed to increase density. Density may also be secured by changing the method of weaving—a process used in the production of the thicker forms of woven lining. Impregnations in woven types of linings may be any of the following materials, used either separately or in combination—asphalts, tars, pitches, condensation products, drying oils or other similar materials. The woven asbestos tapes are saturated with the impregnating compound or compounds by various processes, after which the material is heat treated to fix the compounds, and then calendered or pressed to size. Woven linings are generally better suited for the higher peripheral speeds, and show less "fading," or drop in coefficient of friction under excessive temperature conditions, than do the Folded and Compressed types of linings.

Rigid or Moulded Materials are those made from an asbestos base, bonded with binders such as rubber, drying oils, condensation products, or other suitable materials and then heat-treated to form a strong, dense product. The mass, formed in moulds under heat and pressure to the exact shape desired, makes a compact homogeneous structure. The popularity of rigid friction materials has brought about these accepted divisions; 3/8" thick and under, being termed moulded linings, whereas the irregular shaped and thicker pieces are known as friction blocks. However they are essentially of the same general composition and all may be termed moulded friction materials. In view of their high mechanical strength, moulded friction materials are used where they are subjected to rather excessive stresses which would tend to break down the softer and more flexible types of friction materials. The moulded material, being formed under pressure and the bond being set at comparatively high temperatures, becomes more resistant to temperature. It will show a more constant coefficient of friction over a relatively wide range of temperature than will the flexible types.

Friction discs, cone clutch facings and other

special pieces can be hand or die-formed, moulded or die-cut, from any of the flexible or rigid friction materials discussed above.

Impregnations and Binders

An asbestos fibre base, in itself, is not an adequate friction material. It requires the addition of an impregnant or binder. Besides holding the structure together, the impregnant, or binder, increases or decreases, the frictional characteristics of the finished lining, and also resists absorption of oil, grease or water. Impregnations are introduced into woven tapes or similar structures by solvents which are later evaporated. "Saturants" or "Impregnants" are terms often used to express the same thing. "Binders" are those materials which are employed to bond the asbestos, as in the case of rigid or moulded forms of friction materials.

Impregnations and binders usually consist of the following materials, either separately or in combination—asphaltum, tar, pitch, drying oils, rubber and condensation products or resins. These materials may be classified as organic due to their tendency to carbonize under heat. While these materials are heat treated at the time of manufacture, the temperature on the surface of the friction material in service is much higher than that employed in the manufacture, with the result that the impregnant or binder first liquifies and then carbonizes as critical temperatures are reached. The influence of high operating temperatures on the frictional value is first, to reduce it to often surprisingly low values, dependent upon the type of saturant or binder employed, and then to increase it as the gummy stage is reached. After a carbonaceous condition is reached, the friction value may be relatively higher or lower than normal, depending upon the character of the surface formed. In time the surface is worn away, often quite rapidly. This cycle may repeat itself until the friction material is destroyed.

While inorganic binders might appear to be the solution to the problem of temperature influence, such binders are usually quite harsh and abrasive. Experiments with inorganic binders indicate high friction values both at normal and at elevated temperatures. Friction materials with inorganic bonds have proven satisfactory when employed on clutches or brakes operating in oil. However, as this type of clutch is somewhat of an innovation, inorganically bonded friction materials have not come into popular use.

Metallic Friction Surfaces

It is impossible to discuss the subject of friction materials, without taking into consideration the braking surface against which the friction materials must operate. In considering metallic friction surfaces we are not attempting a technical treatise of the subject, but are confining the discussion to field results, and are making certain deductions based on practical experience.

It is generally agreed that cast iron in its various forms, affords the most satisfactory friction surfaces. Considerable progress has been made in the alloying and heat treating of cast irons, so that it is possible to secure metals with relatively high tensile strength which are more resistant to surface checking and cracking under severe service than are the plain gray irons. While asbestos friction materials will erode a cast iron surface, the wear is usually even, and the surface polished and free from scoring. Field experience indicates that the relatively good service given by cast iron, is probably due to its fine granular structure and lack of crystalline growth under heat. It is doubtful if the presence of graphitic carbon in the cast iron has any material effect on its wearing qualities.

Asbestos friction materials will score any plain carbon steel at normal operating conditions. The resistance to scoring is increased as the carbon is increased. Operating experience shows that about .65 carbon is the critical point where maximum service may be expected both from the carbon steel drum and friction material. In the field of the alloy steels, considerable progress has been made with chrome-molybdenum steel drums. These steels seem to be resistant to temperature changes, and will stand extremely severe service without checking or cracking. While we have no definite data yet, field reports indicate that these steels are also quite resistant to scoring. A fracture test of chrome-molybdenum steels shows a fine granular crystalline structure which apparently does not grow under temperature and, therefore, simulates cast irons in this characteristic.

In the case of carbon steels, scoring can be delayed somewhat by the incorporation of lead, graphite or other materials in the friction linings. The lead or graphite seems to coat the metallic surfaces and act as an absorber of the metallic dust abraded from the drum. However, there is a rapidly accelerated wearing and final scoring of the drum as the friction material approaches ultimate wear. This condition is probably due to the final saturation of the absorptive materials built into the friction linings.

Coefficient of Friction

Asbestos friction materials, irrespective of their structure, may be expected to show a coefficient of friction of approximately .4 when operating under normal conditions. Variations of this value are due to such factors as material of drum, its surface condition, temperature, speed and pressure. In general the value of the frictional coefficient will be increased when operating on soft steel and slightly reduced in value as hardness is increased or surface finish becomes polished. When operating on cast iron the coefficient of friction is slightly reduced below its normal value, especially after the surface has become smooth and polished. Additional pressure usually increases the friction value slightly. Where speeds are increased, the value of the friction may be reduced somewhat. These variations are of little consequence as compared with the effect of the temperature on the friction value. It is for this reason that the maximum operating temperature is of greatest interest. When asbestos friction materials are operated at temperatures far in excess of those recommended, the brake or clutch cannot be depended upon to give that uniformity of operation so desirable and necessary for satisfactory service.

Flexible friction materials present variable surface conditions that effect the constancy of the frictional value to a limited degree as wear progresses. This, added to the effect of high temperatures on the binders and impregnations, cause variations which

are most annoying. Rigid materials, however, extend the possibilities of temperature resistance, due to the fact that the binders employed may be given a prolonged heat and pressure treatment. This treatment results in greater uniformity of frictional value at elevated temperatures. Temperatures at which the coefficient of friction becomes erratic—sometimes rising to very high values, sometimes dropping to nearly zero, but never constant—are considered the limits of good design. For satisfactory operation, temperatures should never be over 400° F. for a flexible material, and not over 500° F. for a rigid material.

Rivets

There is some controversy as to the most suitable type and composition of rivet to be used for fastening friction materials to carrying members. As a general rule solid flat head rivets are the most satisfactory type for industrial purposes, although tubular rivets may be used, providing the tubular section does not extend below the metal supporting member, and thus weaken the rivet in shear. Considerable laboratory work has been done on rivets of various compositions and the following conclusions reached. These may serve as a guide as to what to expect under actual operating conditions.

"Rivets tested—Brass and Copper. Results of test on Mild Steel: Brass rivets ran until head was worn away, no cutting. Copper rivets ran for a considerable period and then started cutting.

"Results of tests on Cast Iron Drums—Conditions which would cause heavy scoring on a steel drum have produced no cutting or destructive action on a typical automotive cast iron drum by brass or copper rivets. The test resulted in destruction of the rivet in each case with more or less plating of its material on the drum surface. With regard to resistance of the rivet to abrasion, brass is superior to copper. This order holds throughout the range of speed and pressure combinations used in testing."

The results of these tests indicate that brass rivets are superior to copper rivets for all conditions of service. There seems to be a considerable variation in brass rivets, which suggests that a definite specification be established for brass rivets as to composition, degree of hardness and grain structure of the material.

The number of rivets required to hold a piece of friction material on its carrying member, depends upon the type of material and the service conditions. Generally speaking flexible types of friction material require a greater number of rivets than do the moulded types which, due to their construction, allow a mass action of the rivets. For light weight, high speed, high duty equipment it is generally recognized that one rivet for every four square inches of friction lining area is amply sufficient. The larger the area and the lower the speed, the fewer rivets required. With large bands on slow moving equipment it is possible to operate satisfactorily with one rivet to every twenty square inches of band area.

All rivet holes in friction materials should be carefully drilled and countersunk so that the heads of the rivets are well below the wearing surface of the lining. Obviously the purpose in so doing is to delay the rivet from coming in contact with the drum as long as possible. Some experimental work is being done toward the development of a rivet hole filler, to be used over the rivet heads, and the results to date have been promising.

Dissipation of Heat

Since fundamentally any brake or clutch is a mechanical device for converting mechanical energy into heat energy, the ultimate answer to good braking or clutching operations, is the dissipation of the heat generated. Technically speaking heat is dissipated in three ways—radiation, convection and conduction. Radiation cannot be considered a factor in this problem. Convection is the means of dissipating the stored up or residual heat in the brake bands and drums. Conduction through the metal mass provides for the absorption of the heat generated by any clutching or braking action. It is important to have just as great a mass of metal as possible, since the greater the metal mass the greater the heat capacity, and the lower the temperature for any given series of brake applications. It is always advisable to design friction drums with as many ribs and cooling surfaces as possible, so as to increase the convection losses to a maximum. It is recognized in suggesting increased metal masses, that increased flywheel action will result. However, where the flywheel action is serious, the difficulty might be overcome by the adoption of pre-cast aluminum cooling vanes, which will not only lighten the construction, but will materially increase the heat dissipating capacity of the drum through the increased conductivity of the aluminum.

Considerable development work has also been done toward completely enclosing brakes and clutches in an oil bath. This construction has resulted in increased clutch capacity due to better heat dissipating characteristics.

Conclusion

In conclusion we recognize that several types of friction materials are required to meet the varying field conditions, for the single perfect friction material has not yet been developed. We realize certain definite limitations in the application of asbestos friction materials as briefly outlined in this paper. If the designers and operators will keep these facts in mind when building and operating equipment, much improved operating conditions will result.

Discussion

Discussed by

C. F. Ogren, Research Engineer, Thermoid Rubber Company, Trenton, N. J.

F. C. Stanley, Chief Engineer, The Raybestos Division of Raybestos-Manhattan, Inc., Bridgeport, Conn.

J. W. Hemphill, Jr., General Power Products Dept., Johns-Manville Sales Corp., New York, N. Y.

J. L. Brown, Mechanical Engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

J. A. Burg, Mechanical Engineer, Electrical Dept., Carnegie Steel Co., Munhall, Pa.

R. F. Kintzing, Control Engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

J. L. Lundberg, Engineer, Dravo Contracting Co., Pittsburgh, Pa.

C. B. Withgott, Engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

B. H. Kersting, Mechanical Engineer, Dravo Contracting Co., Pittsburgh, Pa.

C. F. Ogren: I wish to thank Mr. Hemphill personally for his very able and enlightening paper on the subject of "Friction Materials." Covering the subject so fully in so short a time is an achievement.

Mr. Hemphill mentioned early in his paper that the use of gasoline and Diesel engines had brought the question of clutches to the fore. It is interesting and useful to note that there is quite a difference in the demands on a clutch due to the use of Diesel or of gas engine as the motive power. One of our customers substituted Diesel for gas engine power but kept the same size clutch for the same mill, which had been eminently satisfactory for gas engine power and it fell down quite badly. On looking into the situation we began to realize that the gas engine is much more flexible. It will drop its speed and pick up with the load, whereas Diesel holds to a uniform speed. We found we had to increase capacity of the clutch and size of the facing at least 50% to give proper clutch capacity.

I was glad to hear Mr. Hemphill stress the problem of "heat" as he did. It has been my experience that the question of proper heat dissipation is the greatest problem in connection with the industrial applications of friction materials. He has given 500° F. as a safe working temperature. Materials are being improved—both as to flexible and rigid types—and we hope that we can go above this temperature of 500°; but certainly it does not hurt to have this as a mark to shoot at. We are finding ways of maintaining more uniform coefficient of friction even under increased heat. If temperatures could be kept below this 500°, the makers as well as users would have little to worry about. It is only when temperatures reach a higher point than this that excessive wear and erratic action takes place with the present-day friction materials.

One of Mr. Hemphill's suggestions was that the metal mass of the brake drum or the clutch plate should be increased and supplemented with veins or ribs. I would like to emphasize the necessity for providing sufficient metal mass to draw the heat away rapidly by conduction as it is the only effective way of keeping the braking surface down to a fair operating temperature. Here is an illustration of what metal mass does and the resulting greater service of the clutch or brake material; on a single plate automobile clutch which carries an extremely heavy load, one face rubs against the fly-wheel, the other against the pressure plate. The fly-wheel has eight or ten times the mass of the pressure plate. You will find the wear of the facing on the pressure plate side double that of the fly-wheel side.

Some slight helps in cooling are obtainable also by proper application of the facing material. In the case of a band brake it is often found helpful to apply the lining in short lengths with an air-gap of about 1" between the lengths. This makes a more flexible brake which gives easier action and, at the same time, has quite a decided effect on the cooling. In applying lining in this fashion, it is advantageous to bevel the edges of the lining so that the sharp edge does not rub against the drum to cause a scraping action. The idea of leaving a gap between sections of lining also applies to cone facings and to flat clutch plate installations.

In the field of clutch or flat plate type installations there is one design which is subject to criticism. Manufacturers often will use a friction facing of large outside diameter with a very small center hole, expecting to increase the clutch load carrying capacity by this increase of contact area. It can be readily seen that under such conditions the rubbing velocities at the inside diameter and the outside diameter are quite different and give a decidedly unbalanced action. In most cases it is found that the clutch action is actually improved by cutting away more material at the center of the facing. We consider that the inside diameter of the facing should be at least half of the outside diameter for effective service and leaving more material in the center of the facing is of no advantage but rather a hindrance from the standpoint of wear and equality of action in service.

You gentlemen will doubtless note in the coming year a decided move on the part of automobile manufacturers toward cast drums despite the increased weight and cost. They have been studying this subject very earnestly during the past few months because of the added burden the braking system must carry due to free wheeling. Particular

compositions are being studied and a wide range of results in cast drums has been found. Mr. Hemphill mentioned the composition of some good cast drums. You might be interested to know that one manufacturer of higher grade cars has found the following composition most suitable:

Combined carbon	.50— .70
Free carbon	1.80— 2.00
Silicon	2.10— 2.40
Manganese	.30— .50
Molybdenum	.40— .60
Phosphorus	.20 max.
Sulphur	.09 max.
Steel (good grade)	40. —45.

This gives a tensile strength of 50,000#/sq. in. and a Brinell hardness of 233-262.

F. C. Stanley: I listened to this paper of Mr. Hemphill's with a great deal of interest and find it presents a very accurate picture of the industrial use of asbestos material. There are a few technical points which I would like to enlarge upon rather than criticize:

In the first place, I want to speak of the composition of this asbestos material. I was inclined to criticize the statement that it is a "calcium magnesium silicate." Our laboratories have made a great many analyses and we find the calcium content never exceeds two per cent, so we are inclined to call it "magnesium silicate" rather than "calcium magnesium silicate."

As to temperatures at which this material gives up its combined water, we have a little criticism of that, and I wish to state the authority on which this criticism is based: About seven years ago Consolidated Asbestos Mines Limited* established a fellowship at the Mellon Institute and appointed an honor student to investigate the properties of asbestos. This young man who acted as the "fellow" supported by the company named, spent considerable time on just this problem of determining the temperatures at which chrysotile gives up its water of composition. I know that a great deal of study was given to methods of determining this. You all probably know that asbestos is a hygroscopic material. It will absorb from two to four per cent of moisture from the atmosphere and it was necessary to develop a special means of weighing this material in a vacuum in order to arrive at very accurate determinations. After correcting for moisture it was determined quite accurately that in case of the pure chrysotile the initial giving up of water took place at 800° F. and it lost its last portion at 1500° F.

If we have this type of asbestos, that would seem to raise somewhat the temperature at which we may use the asbestos safely. All brake linings, however, contain organic material and as all organic material undergoes destructive distillation at 500° F, we must say that Mr. Hemphill's limit of 500° F is perfectly just, because of the organic material which the brake lining must contain, but as far as the asbestos is concerned, I think it will safely stand up to 800° F.

Where brake linings are used for purposes demanding severe punishment, as for instance in the lowering of casings in oil wells when they extend as they do in some of the regions 10,000 feet, the pipes are handled very rapidly indeed and the momentum of the whole pipe line has to be absorbed by the brakes. These have water-cooled drums. What they really use is a spray of water upon the brake bands and on the drums. The water is changed into steam immediately and the actual contact of the lining with the drum is absolutely dry.

Some of the linings when they are removed from these bands which were used on this deep well drilling contain beads of iron. This iron melts at 2100° F. When we get these beads of iron we have perfectly conclusive proof of melted material. These beads of iron are about ⅛ of an inch in diameter. This proves we have developed a temperature of 2100° F, surface temperature to be sure, much more rapidly than it can be conducted. The fact that this is a surface temperature is proven conclusively in this case because drums do not become red, and the lowest red is only 960° F.

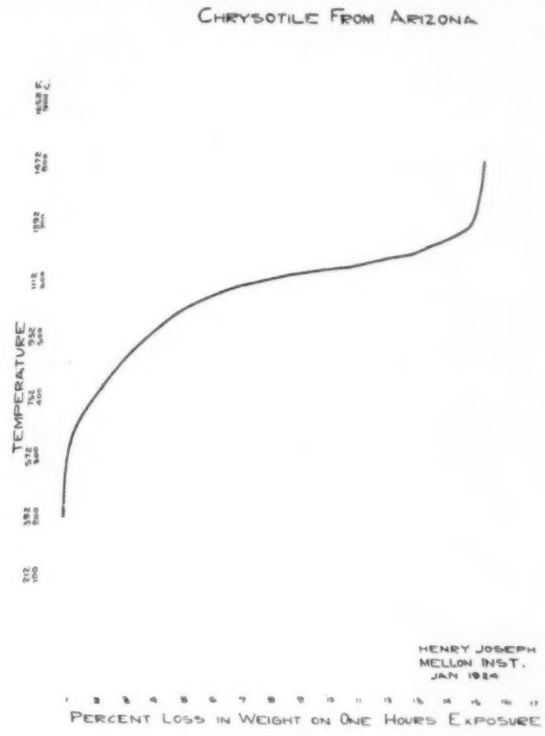

FIG. 1.

The Bureau of Standards attempted to use brake linings absorbing a very large amount of power, two horsepower per square inch, employing a water cooled drum. Linings were attached by copper rivets, and these rivets were melted when in contact with the water cooled drum. Another case where surface temperature was developed more rapidly than it could be conducted.

In regard to the remarks about the most efficient way to dissipate the heat developed by friction, we had occasion to build a clutch to take the place of a transmission. The particular car was a railroad car used for carrying workmen or inspectors on railroads. This car was built by the Fairbanks-Morse Company. They wished to have a clutch that would take the place of a transmission.

* Charts and historical information are furnished by the courtesy of C. J. Stover of "Asbestos."

We designed this clutch with as large and heavy parts as possible and with just as large cast iron pieces as we could put in it. We were able to slip the clutch constantly with full motor torque for eight hours without destroying the facings. The motor developed 8 H.P.

In another case, we were asked sometime ago to arrange to absorb the heat developed in a centrifugal clutch on a motor. The motor was a small ½ H.P. type, but the designers wished to run at constant speed and still drive a generator at a much lower speed. This meant constant slipping of this centrifugal clutch. We calculated that the slipping generated four-fifths of a B.T.U. per minute.

The designers expected by means of fins on the rotor to develop a means of carrying air through the clutch in sufficient quantity to keep the temperature down. A few calculations showed us that in order to keep the temperature from rising in this case, it would be necessary to carry 18 pounds of air through the clutch every minute. This is very evidently impossible, and is given as evidence that we find cooling by convection a very inefficient means, because of the low specific heat and lightness of air.

J. W. Hemphill, Jr.: Mr. Ogren remarked about putting linings on in short pieces. We have tried this construction on many jobs, even to putting the pieces on so that the spaces between the linings angled across the drum. In some cases this method of application was found effective, in others the results were not noticeable. There is a general inclination on the part of designers in the Industrial field to prefer the increased friction area than the spaces between the linings.

As to Dr. Stanley's remarks relative to temperatures at which the water of crystallization of Asbestos is driven off, would advise that I am not

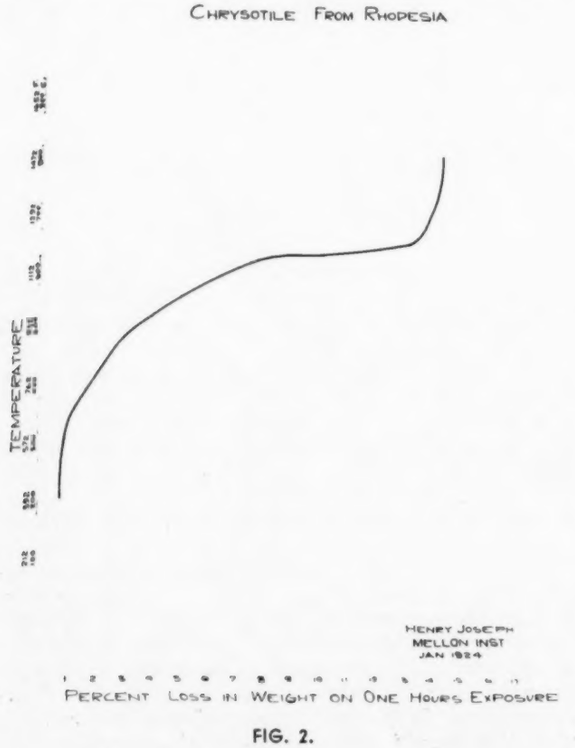

FIG. 2.

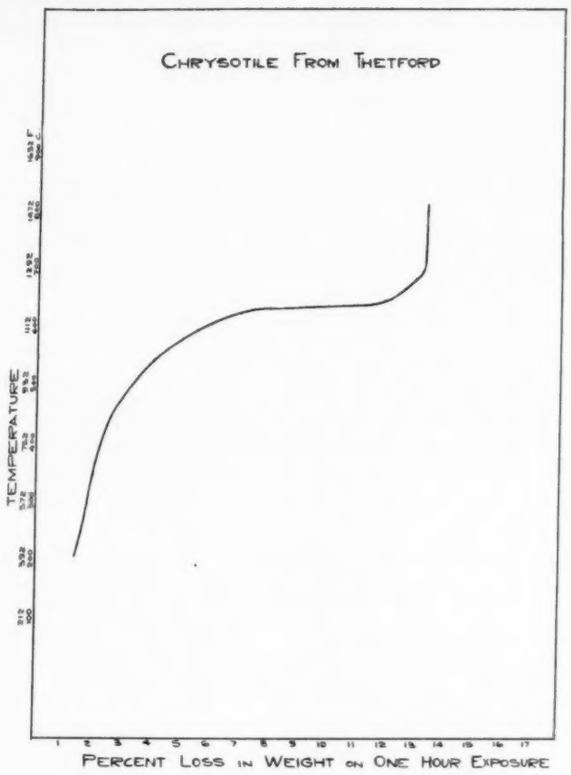

FIG. 3.

enough of a chemist or physicist to argue the point. There is no doubt but what the different methods of determining these temperatures would materially effect the results obtained.

Some of the manufacturers of rotary draw works are using enclosed water-cooled brakes. This is accomplished by welding a jacket on the under side of the brake drum and piping water from a suitable reservoir or storage tank. While water-cooling has helped some, yet the operators are still having considerable difficulty with drum scoring and rapid wear of lining. All of which would indicate possible surface temperatures above the critical temperature at which Asbestos friction materials can be operated although scored drums will materially reduce the life of the lining.

J. L. Brown: I should like to inquire as to the cause and cure of screeching of brakes; whether the cause is in the surface of the drum, or whether in the lining, or in both?

J. W. Hemphill, Jr.: That is quite a difficult problem to answer in all cases, although we believe in the majority of instances that squeak is as much a question of mechanical design as the lining itself. If the design of the equipment is sufficiently rigid, it will not set up the vibrations that cause squeaking. In cases of automotive design, it is primarily by increasing the rigidity of the mechanical equipment that squeaking is overcome. Probably Dr. Stanley would add something to this discussion.

F. C. Stanley: Back in 1927 I read a paper on this subject at one of the S. A. E. conventions in Detroit. It did not take me more than twenty minutes to read the paper, but it took three hours

to answer the questions. What I said then was mostly wrong, and since then I have changed my mind very much as to the cause of squeaking.

Mr. John Snead who invented the Steeldraulic brake eliminated squeaks by strengthening the backing plate or dust shield by increasing its thickness, the composition of the steel, or ribbing it.

It is generally accepted that squeaks can be eliminated in most cases by increasing the surface of lining that is bearing on the drum so as to dampen drum vibrations. Working on that theory will do away with 90 per cent of the squeaks, but they do not all originate in the drum.

When we have these heavy cast iron drums such as used on our busses with ¼" sections, squeaks are probably due to some other cause than drum vibrations. Squeaks on these busses are usually eliminated by making the attachment of lining to shoes so perfect that there is no vibration.

Sometimes squeaks occur because of loose U bolts bolting the springs to the axle. Loose parts will form a squeak of much lower pitch than we get from drum vibration.

J. L. Brown: I should like information as to whether there is any more difficulty in avoiding squeaks with a band brake having a thin piece of sheet metal covering the lining than if a heavy type shoe were used.

J. W. Hemphill, Jr.: I can answer your question in a general way. There would be more tendency for light bands to squeak, more or less noise being created from the vibration of them. The more rigid you can make the construction, the less opportunity for vibration and less tendency to squeak.

A Member: Mr. Hemphill mentioned that the flexible material is used on slow peripheral speed applications and the rigid material or lining is used on high peripheral speed applications. I am wondering what speeds are so-called low speeds, and what are so-called high speeds, also at what speed it would be advisable to change from a flexible to a rigid type of lining.

J. W. Hemphill, Jr.: That is almost as difficult a question as the one on squeaking. Take the case of oil field rotary brakes running at 10,000 ft. per minute—we would call that real high speed. A drum with a speed of 1500 to 1800 feet per minute would be considered normal speed.

B. H. Kersting: We are extensive users of brake band materials for heavy hoisting and dredging machinery, but of late we are using moulded V-type blocks instead of woven lining. We found that for band brakes the blocks are more economical than woven lining due to the fact that the worn blocks can easily be replaced with new ones, without removing the band from the drum. We also take advantage of exchanging the worn blocks at the tight end of the brake band with those only slightly worn at the loose end of the band, and in this way, we obtain maximum service from the blocks. The wear on the woven lining occurs mostly for a length of about one-third of the circumference at the tight end of the band, thus resulting in a considerable waste of brake band material and labor for making replacements.

I have noticed, that considerable steam and smoke is generated from the blocks on several installations where the service has been extremely severe, and I am asking Mr. Hemphill if this condition abnormally shortens the life of the blocks as it is my understanding that the composition of these blocks contains a large amount of moisture.

We have experienced a great deal of trouble, due to scoring of brake wheels and drums. This scoring has occurred on cast iron, nickel cast iron and particularly on untreated cast steel wheels which has considerably reduced the service of the blocks. I have noticed for a number of years back that the brake band material manufacturers have been offering linings and blocks with an extremely nigh coefficient of friction (up to .40) for their recommended brands. It is my belief that this guarantee of such a high coefficient of friction has induced the designer of brakes to reduce the size of the wheels or drums to such an extent as to result in undue wear, scoring and overheating of brake drums. It may also be said that the metallurgist has not kept up with his development to our present requirements for brake drum materials and it would be well for the brake lining material manufacturers to look into this part of the brake problem.

Since the coefficient of friction for brake materials has been increased to as high as .40 it has undoubtedly become more abrasive and destructive for the drum, than would be obtained of a material with a lower coefficient of friction. I am asking whether or not it would help our brake drum situation if the coefficient of friction would be kept down to a lower figure and following in this trend of thought I may mention the cast iron brake shoes as used by the railroads with a coefficient of friction of approximately .10 and this coefficient does not seem to result in any scoring on either locomotive tires or car wheels.

As there are a good many applications on which the drum diameter must be kept small due to space limitations and weight, it becomes necessary to find a better and harder material for the drum, and in this connection I am asking Mr. Hemphill what results he has observed using case hardened drums such as are offered by the Tool Steel Gear & Pinion Company of Cincinnati, Ohio.

J. W. Hemphill, Jr.: As to that puff of steam, the only thing that could cause this condition would be mechanical moisture on the blocks. I can't imagine water of crystallization passing off in a puff of steam. Now as to "smoking" (Mr. Kersting calls it "gas"): smoke is due undoubtedly, in the case of moulded blocks, to the breaking down of the rubber compound holding the block together; with the ultimate carbonization of the bonding compounds. The dryer the block the less smoke, but you are bound to get smoking or gassing when the bond changes from a gummy state to a carbonaceous state.

We all agree, generally speaking, that the lower the coefficient of friction, the lower the rate of wear, but we must remember that as yet we know comparatively little about how to lower the coefficient of friction and permanently keep it there. We have various types of lining with graphite built right into them. Graphitized linings have some very objectionable characteristics. When I speak it is mainly from field experience rather than from laboratory tests. In the field with graphitized linings, we have seen them slip because of very low coefficient of friction. Then ultimately a temperature is built up where apparently we get thermo-plasticity of the

bond which bleeds through the coating of graphite. Then there is a grabbing action and high coefficient of friction which does not tend towards very satisfactory brake and clutch action. I believe most of the people will agree that if we have a friction surface of a granular structure comparable with cast iron, we will not have the abrasive action we do have on steel. In all probability the scoring of steel is due primarily to increased crystalline growth of the metal due to heat. I have examined many drums that were scored and have found cases of broken down crystalline structure on steel surfaces. If we are to do work with a friction material there must be surface resistance and there will always be wear between the two surfaces. The two factors to be controlled in any brake design problem in order to get best results are the type of friction surface and temperature.

In any brake or clutch action that is completed in a definite period of time, a definite quantity of energy is expended and a definite amount of heat generated. With a lower co-efficient of friction we extend the time element out here somewhere (illustrating) then with the same energy expended lower temperatures will result. This is obviously true.

F. C. Stanley: Let us suppose, Mr. Hemphill, that the brake stops the wheel or machine in the same time regardless of the coefficient of friction, will not the same power and the same heat be developed whatever the coefficient of friction, that is, where coefficient of friction is low we must increase the pressure if we are to stop in the same time?

J. W. Hemphill, Jr.: That is right.

F. C. Stanley: In the matter of abrasive, have you not been asked to produce a lining with an abrasive? It has been our experience where we have to have a constant coefficient of friction such as for work in an oil tank, that there has been a demand for incorporation of carborundum in the friction material to give us constant coefficient of friction when working on cast iron. This makes the brake or clutch efficient even when lubricated.

J. W. Hemphill, Jr.: A year or so ago our Research Laboratory did some work on the incorporation of abrasives in friction materials and the results were quite promising. However, due to rush of other work, the tests were never carried to any definite conclusion.

B. H. Kersting: Under what conditions did you experience the scoring in both cast iron and steel?

J. W. Hemphill, Jr.: Scoring of cast iron drums has been noted under the following conditions: Using friction materials having inorganic bonds and run without lubrication; metallic or other foreign substances getting into the lining or block and cutting the surface. We have also seen where hard brass or copper rivets have caused scoring. However, serious scoring seldom occurs on cast iron surfaces.

Ordinary carbon steels are readily scored by Asbestos friction materials. Scoring can be reduced by the use of brass or copper bars of same thickness as the lining and rivetted to the steel brake band. The metal bar extends across the face of the friction material and bears directly on the drum. It acts as a plating material and keeps the steel braking surface smoothed up to some extent. This is standard practice with the Marion Steam Shovel Company and will clean up a scored drum.

J. A. Burg: Does the incorporation of woven brass or copper wire have any effect on the scoring of the wheel?

J. W. Hemphill, Jr.: If you will examine the cross section of a steel wheel (illustrating) you will note that the rivets are in line when there is least wear. In other words, there is greater wear between the rivets where the lining is contacting the drum; consequently, we suggest the use of the copper or brass bars mentioned above.

In the case of cast iron wheels copper or brass wire may have a slight abrasive effect on the friction surface but I have never seen serious scoring under normal operating conditions.

J. A. Burg: Are not brake linings usually made with wire mesh through them; doesn't that reduce scoring?

J. W. Hemphill, Jr.: If the lead is in sufficient mass. Several years ago we did considerable work with lead in friction materials. We started with lead dust and brought up the mass size and only when we got into pieces of lead of considerable mass did we get any advantage from the use of lead incorporated in the lining. The low fusion temperature of lead limits its use considerably.

R. F. Kintzing: Should you expect to get the same coefficient of friction with a moulded lining as with a woven lining and what was upper limit of pressure?

J. W. Hemphill, Jr.: Fabric types of linings present variable surfaces as you wear through the plies of asbestos. I would say as a general proposition you will get more nearly constant coefficient of friction at normal operating temperatures with moulded types of lining than with woven types, owing to the fact that they don't change surfaces as readily as do the woven types.

As to pressures, I believe it is perfectly safe to use pressures on almost any type of lining, so far as operating conditions are concerned, that could be developed with a normal system of levers. As a concrete case: I happened to pick up some data on a band type clutch using a molded form of lining. In this case the dead end pressure was 271 pounds per square inch; average pressure 132 pounds per square inch. This data may answer your question better than any other information we can give you, because it happens to be the data of a shovel manufacturer. If you can control temperature, the linings will withstand any pressure you may normally be able to develop without the use of operating mechanisms such as booster bands or other devices. In this particular case the clutch is operated with a booster band.

R. F. Kintzing: I wanted to know whether there was any difference in the coefficient of friction in the material, as to whether it was woven or moulded?

J. W. Hemphill, Jr.: Under normal conditions regardless of the construction of the material you will get a coefficient of friction approximately .4. It does not make a whole lot of difference whether woven or moulded; you will get about the same coefficient of friction. Woven linings when new or operated under light loads have a certain amount of springiness (generally called adhesion) that causes a greater gripping action and is sometimes confused with coefficient of friction. This action disappears under severe service.

F. C. Stanley: Mr. Hemphill, would it not be

well to explain the difference in bleeding tendency in different types of lining?

J. W. Hemphill, Jr.: May I ask you to explain that.

F. C. Stanley: In the case of a woven lining it is impossible to carry the heat treatment to the same extent as with a moulded lining. Moulded lining may be subjected to a temperature of 500° F in the curing process, and this insures no bleeding up to this temperature. When we are obliged to furnish lining that is flexible, that can be bent or applied to any sort of band, we cannot raise the temperature of the cure to this extent. Our temperatures are limited to about 350° F and if subjected to temperatures above this we get a distillate that lubricates the drum and causes what we call "bleeding" which lowers the coefficient of friction when overheating and produces what Mr. Hemphill describes as "fading."

J. A. Burg: Is the use of this copper bar of any advantage on a cast wheel?

J. W. Hemphill, Jr.: No necessity for putting it on a cast iron wheel. It has its place on steel wheels and we base our conclusions on the experiences of one of the large shovel manufacturers. This company uses cast steel wheels of about .30 to .40 carbon.

J. A. Burg: Would you say .65 C would give best results as regards scoring.

J. W. Hemphill, Jr.: Simply a case of hardness of the wheel. As you increase the carbon and increase the degree of hardness you reach a point where there is apparently rapid wear of the lining, and .65 C seems to be the point where you balance wear of drum against lining life.

R. F. Kintzing: Does case hardened wheel show any better results due to hardness?

J. W. Hemphill, Jr.: From reports we have from the field, the case hardened wheel is standing up satisfactorily and this is apparently due to the hardness of the drum.

J. L. Lundberg: A brake drum, manufactured by a certain firm, is to my knowledge made of low carbon steel and carburized. The depth of the penetration of carbon is approximately 1/3 of the thickness of the rim and the hardness test approximately 85 scleroscope.

The report I have had from the field is that this drum performs satisfactorily.

It is, however, difficult to explain how a case hardened drum can stand up in service when the temperature on the brake drum rises above 450-500 degrees F.

It is obvious that at this or somewhat higher temperature, the hardness of the drum is drawn to a lower grade of hardness when this temperature is constant for any length of time.

My conviction in this matter is that the denseness of the carburated top surface on the drum, which contain perhaps up to 1% carbon, has as much to do with the successful service as the hardness.

A Member: I have a Model A Ford and have been experiencing some difficulty with the front wheel brakes chattering. This chattering seems to occur after the linings have taken up a certain amount of grease from the bearings, and then only when applying the brakes when the car is traveling at a slow speed. If the car is traveling at a speed greater than 15 miles per hour, applying the brakes will cause no chatter. I would like to know if the grease on the brake linings is the cause of the chattering or whether something is worn in the front end assembly and this is causing chattering. If the chattering is due to the grease on the linings, would the use of a rigid lining eliminate the chattering?

J. W. Hemphill, Jr.: I imagine you have a Folded and Compressed or Rubberized type of Lining on the front brakes. With this type of lining the grease would, undoubtedly, attack the rubber content to a certain extent and cause a surface softening. This condition would bring about a decidedly variable co-efficient of friction which might develop chattering. Running the brakes hot would help to dry the lining and bring it back to somewhere near normal. However, this procedure sometimes results in glazed brakes which have little holding power. Glazed linings can be helped materially by removing the bands and cleaning the surface of the lining with sandpaper or a file, thereby, eliminating the necessity for changing the linings.

As Dr. Stanley pointed out, moulded linings are heat-treated to higher temperatures than flexible materials, with the result that these types of linings are more resistant to the action of heat and grease. This fact alone would help brake operation. The moulded types of friction materials also show a greater tendency to break the surface tension of oil or grease on the drum surface, and consequently, recover their frictional value much more rapidly than do the fabric types, which have a tendency to absorb some of the grease or oil.

J. A. Burg: In regard to the heat treated wheels, we have had them in use for some time. These wheels are of ordinary steel .50 to .55 C, forged, rough turned and then heat treated on the face to close the grain and give a hard surface. A light finishing cut is then taken off the face. We have had some of these wheels in use on shipping crane hoists for 3 years and have found them to be very satisfactory, no scoring having taken place. Very nearly all our brake wheels being made today are of the heat treated type.

C. B. Withgott: It was stated that coefficient of friction was rated as .4, does that change considerably with change in temperature?

J. W. Hemphill, Jr.: Up to certain temperature limits there is not an appreciable change in coefficient of friction. However, when critical temperatures are reached where the organic bond becomes plastic, decided changes in frictional value occur. (Illustrating). As a general rule, if the high temperature is maintained there will be a sloughing off of the surface of the lining and a repetition of the cycle until the lining fails.

C. B. Withgott: Will the coefficient of friction be greater with moulded lining or with woven type?

J. W. Hemphill, Jr.: There will be less fluctuation of coefficient of friction due to temperature with a moulded lining than with a woven or fabric type.

F. C. Stanley: This change in coefficient of friction at high temperature is due to bleeding, that is, due to destructive distillation of the binder much more than to the plastic or thermo-plastic condition of the lining itself. We may have produced a considerable quantity of the distillate or tarry substance which may lodge on the hot drum. In some

cases the drum may be hot enough to evaporate it completely, and in another case there may be such a large quantity of distillate produced that it remains as a lubricant. It is my opinion that this erratic distillation or "bleeding" is the cause of the irregularity of coefficient of friction which occurs at temperatures beyond those at which the lining was baked or cured.

C. F. Ogren: As to the maximum pressures that can be used, that is determined by the heat generated and is intimately hooked up with rate of speed at which the machine operates; and as far as mechanical strength is concerned, enormous pressures can be used. There used to be a more or less empirical formula where feet per second multiplied by pressure per square inch was given a value of not over 6,000, but I think that is out of date now compared to present practice.

One gentleman, during the discussion, brought up a question on the Ford brake with which I have had considerable experience in the last couple of weeks; that is, the chatter problem on the front wheel. In the first place, with woven linings we usually find that this is quite severe. With moulded linings it is quite a bit less than with rubberized linings. However, moulded linings have quite a drum scoring action which make them unsuitable.

To find out where this front brake chatter occurs, I have been riding the front bumper and placing my hands on various parts of the brake mechanism as the brakes were applied. No vibration is found in the drum at all but the backing plate,—or dust shield,—does a regular song and dance. You notice it distinctly when you put your hand on the backing plate, but not until you get down to about 5 miles per hour. Then you get the chatter for the balance of the stop. The Ford backing plate happens to be 1/32" lighter than any other used in the automobile industry. While this is out of the field of industrial application, it emphasizes the need for rigid construction and rigid mountings.

▲

Lubrication

Past – Present – Future *

Fifty years ago machinery did not require the attention as it does of our time. There are standing today windmills seventy-five years old, with wooden journals, wooden bearings and wooden gears. These were lubricated with tallow and grease made from fats and resin. The journals, while some worn, have a burnished surface, and the gears, while worn to some extent, are in a smooth condition. Blowing engines, within a few years past, were in use with wooden air cylinders and wooden pistons; these were lubricated with tallow and water.

Rolling mills fifty years ago were lubricated with fats, suet for warm work and pine pitch for gears and cheap oil for general use. These machines did very well lubricated as they were.

During the past thirty years there have been great changes in both design of machinery and quality of lubricants. Today there are many old machines in use which the advanced quality of lubricants, the modern lubrication devices, plus the ingenuity of men have prolonged to a great extent their earning power.

Since the World War the design of machinery, refining of oils and compounding of greases have advanced with leaps and bounds. The demand for greater production has brought forward greater speeds and higher pressures, especially in the rolling mill machinery. It has taxed the metallurgist to keep abreast of the demand for better material in all the parts of machinery. Along with this came the demand for better lubricants. So today all concerned in the better operation and lower maintenance cost of production are keen to the necessity of proper lubrication.

Today we feel that we have almost reached the mecca of efficiency. Locomotives, rolling mills, electric motors, in fact all kinds of machinery are being equipped with anti-friction ball and roller bearings; wood and composition bearings are being used in many unthought of places; babbitt and bronze metals are being made to withstand greater pressures with less friction; lubrication devices for the application of all kinds of lubricants are being perfected;—all to one end, the reduction of power load and maintenance cost. So with every advance step of modern machinery, lubrication must advance with it.

What can we say for the future? Many will say we are living in the present age why care for the future. To be progressive we cannot remain satisfied. Machinery will improve to one end,—greater and better production. If this is so, the manufacturer of lubricants must improve his product; the lubrication engineer must be alert and competent; otherwise the purchaser of machinery must suffer the loss. In a great measure the machine owner is the experimental laboratory of today. Therefore, the designer of machinery and the producer of lubricants should be in a position to say, without any question, what lubricant one should use for every type of machinery.

That the best result should be obtained the lubrication engineer should be a practical man; he should be a real mechanic; he should be able to diagnose the wants of the machine; he should know the properties of the lubricant and where it should be applied; otherwise, all of the study and labor of engineering organizations will come to naught.

The lubrication of a machine is to a great extent the length of its life. Therefore, the study of lubrication is a great factor in the future economy of all manufacturing business. This being so, whatever can be done in co-ordinating the efforts of engineering, refining of oils, compounding of greases and designing devices for applying lubricants should be pushed to the greatest extent.

* Contributed.

Lubricating Steam Cylinders

▲

(Continued from March Issue)

Filtration. Steam cylinder oils are sometimes filtered to improve the color and to make them atomize more quickly. The process of filtration removes some of the hydrocarbons which make the oil cohesive and it is then possible to feed smaller drops with a hydrostatic lubricator. For the same reason the oil drops, when they reach the steam line, are more quickly divided or atomized.

Filtered cylinder oils should be used with care, however, as they do not adhere to the cylinder wall in the presence of moisture, as well as non-filtered cylinder oils.

Making the Oil Stick. When the oil has been properly atomized and thoroughly distributed throughout the steam, it will be carried to all parts requiring lubrication, including valves, valve rods, cylinder walls, piston rods. Whether it will adhere to these parts, and remain there as it should to prevent wear and reduce friction, depends upon a great many things.

First of all, the oil should be able to stick to the metal. Any kind of oil will stick to dry metal without any difficulty, unless it is so hot that it is immediately vaporized like water on a red-hot plate.

When the metal surface is constantly bathed in steam, or scoured by water containing various chemicals, it is not such a simple matter, and the oil must be made so that it will adhere and lubricate under such conditions.

Viscosity. Assuming that the oil will adhere to the cylinder wall in a proper manner, the next question is the amount adhering to the wall and the factors that effect it. Other things being equal, an oil of high viscosity will form a thicker film than one of low viscosity. A thick film of oil naturally will have a better opportunity to prevent the piston and rings from rubbing together in such a way as to cause wear.

The viscosity, of course, varies with the temperature, and at the temperatures existing in the steam cylinder, the viscosities of all oils are very low, but the percentage difference in the viscosities is very nearly as large as it is at 210°F., the temperature at which the viscosity is ordinarily measured, and on this account there is quite a marked difference in the service given by oils of differing viscosities.

From the statement just made, that a thick film will have a greater tendency to prevent wear than a thin film, it might be thought that oils of high viscosity would be the best in all cases. There is a limit to the viscosity which can be used, however, because the high-viscosity oils are not atomized as readily as those of lower viscosities, and instead of improving the film the high-viscosity oil might fail to form a good film at all. This would certainly be the result if all the oil, or a good portion of it, were carried straight out to the exhaust with the steam because it could not atomize properly, owing to its high viscosity. Under such conditions, lubrication could be improved by the use of a lower-viscosity oil.

Temperature has another effect on the oil film, because as it reduces the viscosity of the oil, it lowers its resistance to being wiped off the cylinder by the piston and rings. At high temperatures, such as those due to superheated steam, the viscosity is lowered materially, and in order to maintain sufficient oil on the cylinder wall it is sometimes necessary to raise the initial viscosity of the oil.

Volatility. Another element affecting the amount of the oil adhering to the cylinder wall is its volatility. The volatility increases with the temperature, so that, at high steam temperatures, a much larger amount of a given kind of oil is required to maintain a proper oil film than at lower temperatures. An oil that is entirely satisfactory at 338° F. (100-lb. pressure) might not be at all suitable at 370° F. (170-lb. pressure) because it would evaporate too fast at the higher temperature. Some engines operate on steam at 200-lb. pressure with 150 to 200° superheat, and at such temperatures as 538 to 588° F. just any kind of oil will not do.

Many engineers attempt to select the oil to meet such temperatures entirely on the basis of flash point, assuming that volatility is directly related to flash point. While there is, of course, a connection between the two, since the flash point is caused by the volatility of the oil, the rate of evaporation or volatilization of two cylinder oils at the temperatures and pressures existing in the steam cylinder may be in proportions quite different from their respective flash points at atmospheric pressure.

The volatility depends upon what the oil is made of and the relative amounts of the different hydrocarbons which it contains. A distillation test perhaps would be more satisfactory for purposes of comparison than the flash test.

Incorrect Volatility. An oil that is too volatile will evaporate off the cylinder walls under high temperatures as rapidly as it can be put on by the steam. Furthermore, when the oil is thoroughly atomized and mixed with steam, it is in the ideal condition for vaporization. It is, consequently, quite likely that a considerable amount of vaporization takes place before the oil ever reached the cylinder walls. Such a state of affairs will require the use of large quantities of such an oil in order to get a satisfactory lubricating film on the cylinder wall.

The vapor condenses to a certain extent when the steam brings it into contact with the cylinder, which is at a lower temperature than the steam itself. This condensation aids in the formation of the film. A cold cylinder wall would probably hold a greater film than a hot cylinder wall if it were not for the bad effect of the larger quantities of moisture which would exist on the colder walls.

Mechanical Conditions. The mechanical condition of the cylinder, piston, and rings, also affects the formation and maintenance of the lubricating film. When cylinders wear out-of-round, the piston and rings do not fit properly and there is an excessive load on that part of the cylinder supporting

the weight of the piston. Worn rings with sharp edges tend to scrape the oil off the wall and permit metallic contact and wear.

Presence of Moisture. Steam that has not been superheated will carry, by the time it reaches the engine cylinder, moisture in varying amounts.

Washing Effect of Moisture. Pure mineral oils and water each have about the same ability to wet, or to adhere to, metal, with water having a little more affinity than the oil. If the metal is wet with water it is difficult to make the oil stick; when it is wet with oil, the water will not displace it readily. If, however, a large quantity of water is thrown onto the oil film, or if a considerable number of drops of water strike the oil with considerable velocity, it will have a tendency to scour the oil film off and replace it with a water film. Except in dry steam, the amount of moisture is far greater than the amount of oil present, and the oil film is quite likely to be entirely destroyed.

Resistance of Different Cylinder Oils. The washing effect of a small amount of moisture can be overcome to a certain extent by increasing the amount of oil fed to the cylinder, and by using certain kinds of mineral oils which emulsify slightly with water. A highly filtered cylinder oil, for instance, has little tendency to emulsify, and is of practically no value for lubrication where moisture is encountered in large quantity. A steam cylinder oil which has not been filtered contains certain constituents that assist in the formation of a slight emulsion in the presence of water, and this emulsion seems to be able to adhere to the metal better than the straight mineral oil. Another explanation is that the unfiltered oil, once on the metal, adheres better than the filtered oil in the presence of water, and will not wash off so readily.

Low-pressure Cylinder Lubrication. The low-pressure cylinder, because of its low temperature and the amount of moisture present in the steam, requires a well-compounded oil. It is then necessary to feed considerable quantities of oil into the low-pressure cylinder in order to lubricate at all. When the steam leaving the high-pressure cylinder is fairly dry, owing to the steam having been initially superheated, very little compound is removed from the oil, and the low-pressure cylinder is much easier to lubricate.

Superheated Steam. Steam cylinders using superheated steam have come to be regarded by many engineers as being particularly difficult to lubricate. When superheat was first used, many considered it necessary to get the highest flash point and highest viscosity oils that could be found. It was thought that the high temperatures would burn up a low flash oil so rapidly that it could not remain on the cylinder wall long enough to do any good. It was also claimed that the high temperature would thin the oil down to a point where it would not prevent wear of the cylinder. It was believed, furthermore, that a compounded oil, such as was used for the lubrication of cylinders using saturated steam, would be very undesirable on account of carbonization or decomposition.

Conditions in the Cylinder. Let us consider the general cylinder conditions: The average so-called superheated steam engine installation receives steam from the boilers at pressures ranging from 150 to 175-lb., and superheat amounting from 75 to 100° F. at the boiler. By the time the steam reaches the engine it has lost a good bit of its superheat, and after passing through the valves on its way to the cylinder, it has lost a good bit more, so that when it actually enters the cylinder it carries very little superheat at all, and this is entirely disposed of shortly after expansion starts. Throughout the remainder of the expansion stroke, the cylinder wall is in direct contact with steam which is increasing in moisture content, and during the entire period of the exhaust stroke wet steam is in continuous contact with the oil film on the cylinder wall.

Such conditions differ very little from the ordinary steam engine cylinder conditions, except for the quantity of moisture present, and the same sort of oil should be used for both conditions. The usual type of superheat cylinder oil—high viscosity, straight mineral oil containing no compound—is obviously quite unsuitable for maintaining a lubricating film under these conditions. It is too viscous to atomize properly at the operating temperatures, and it cannot adhere to the cylinder walls because of the moisture.

On the other hand, when a medium viscosity, compounded cylinder oil is used, such as would ordinarily be recommended for wet steam conditions at the same pressures, no trouble whatever is experienced.

With steam at 150-lb. gage and cut-off taking place at about one-quarter stroke, it has been estimated that, in order to produce any superheat in the exhaust steam, approximately 200° of superheat is required at the throttle. At all degrees of superheat below this, on the exhaust stroke at least, moist steam has to be contended with, which always requires the use of a compounded oil, and even then lubrication is quite likely to be unsatisfactory.

Carbonization. Serious trouble from carbonization of the oil has been experienced in engines operating at high steam pressures and a high degree of superheat, most of it being due to an entire disregard for the presence of moisture in the cylinder. When a straight mineral oil of high viscosity is used, similar to practically all so-called superheat cylinder oils, the influence of moisture cannot be counteracted. The engineer observes that he is not getting proper lubrication and increases the feed of oil in an attempt to take care of it. The high viscosity oil usually has a very low volatility and does not evaporate very quickly. When the large quantities supplied in the engineer's attempt to get lubrication are greater than can be atomized or evaporated, the oil will collect in a liquid state in any portion of the valve chest or cylinder where a depression exists. This pool of oil subjected to the high temperature of the steam slowly carbonizes, and as soon as the deposit is built up high enough, bits are broken off and carried under valves, causing them to wear.

Oils to Use for Superheated Steam. All of this trouble may be eliminated by providing for thorough atomization and complete evaporation of the oil as soon as it has done its work of lubrication. If a slight percentage of compound—2 or 3 per cent, or even 5 per cent—be added to the oil to take care of the lubrication of the cylinder on the exhaust stroke, the quantity of oil fed can be greatly reduced. As soon as the quantity supplied is reduced

to the point where perfect atomization follows, there will be no opportunity for pools of oil to collect, and there will then be no carbonizing.

Instead of using the highest possible viscosity, use a medium-bodied oil, one that will atomize readily, and having been properly atomized, will provide proper lubrication for the cylinder. Having selected the proper viscosity, add from 3 to 5 per cent of compound to take care of the moisture.

When extremely high temperatures are encountered, such as 250-lb. pressure and 200° of superheat, the viscosity must be increased and the boiling point of the oil raised in order to prevent such rapid evaporation of the oil that it will not adhere to the cylinder wall long enough to lubricate.

Summary of Cylinder Lubrication Principles. A lubricating film is most easily formed when the cylinder oil is completely atomized.

Complete atomization depends upon steam temperature and moisture content, upon steam velocities and mechanical atomizing appliances, upon viscosity and surface tension, and upon the time allowed before the oil reaches the cylinder.

High temperatures improve the atomization of the oil; low temperatures retard it and make it necessary to use quick-atomizing oils.

Mechanical atomizer's and a suitable arrangement of the feed lines improve the atomization of an oil. They are sometimes quite necessary for the proper atomization of viscous oils.

Oils of low surface tension are more completely atomized than those of high surface tension.

Introducing the feed of oil some distance from the cylinder allows more time for proper atomization of the oil before it reaches the cylinder wall.

Better results can be secured by feeding the oil into the steam line 6 to 8 ft. above the throttle than just below the throttle or directly into the steam chest.

When the point of oil introduction is close to the cylinder, quick atomizing oils are required.

Low-viscosity oils are more readily atomized than high-viscosity oils.

Filtered steam cylinder oils atomize more quickly than those that have not been filtered.

Moisture in the steam improves the atomization of the oil.

Compound in the oil improves its ability to atomize.

High steam velocities improve the atomization of the oil, although they allow a shorter time for the complete atomization before the oil reaches the cylinder.

Maintenance of the lubricating film on the cylinder wall is affected by the steam temperature, velocity, and content of moisture, by the adhesion, viscosity, and volatility of the oil, by the speed, pressure, and design of piston and ring, and by the character of the cylinder metal.

High steam temperatures tend to evaporate the oil off the cylinder wall and necessitate the use of more oil, or less volatile oil.

High steam temperatures reduce the adhesion of the oil, and it is more susceptible to the scoring action of the moisture and steam velocity.

Moisture in the steam is detrimental to the oil film, because it tends to wash it away.

The adhesion of the oil under conditions of moisture may be improved by the addition of compound to the oil.

Non-filtered, steam-refined, cylinder oils resist moisture better than filtered cylinder oils.

High-viscosity oils resist the rubbing action of the piston better than low-viscosity oils.

High-viscosity oils are less susceptible to scouring by steam and moisture.

Oils of low volatility will remain on the cylinder wall for a greater length of time after the engine is shut down than those of high volatility—a great advantage when the engine is operating at irregular intervals.

Oils of low volatility are more economical in forming a film than those of high volatility.

High piston speed rubs the oil film off rapidly and requires more oil to maintain the film.

High piston ring pressures tend to scrape the oil away.

Filtered cylinder oils separate from exhaust steam more readily than non-filtered oils.

Straight, mineral oils may be removed from the exhaust steam more completely than compounded oils.

Steam-refined cylinder oils are made in a number of grades according to viscosity and volatility, those of low volatility being more expensive than those of higher volatility. This is one very good reason why the cheapest possible oils should not be used where conditions are likely to cause them to evaporate rapidly. Viscosities range from 90 to 200 sec. Saybolt at 210° F.

Filtered cylinder oils are made from the same stock as steam-refined cylinder oils, but though having been filtered, the heaviest hydrocarbons and the more adhesive ones have been removed. This makes the oil translucent instead of opaque, as are the non-filtered, steam-refined oils.

Because of the many variables in individual installations, it is not possible to make a single recommendation of one brand of cylinder oil to meet all conditions. The peculiarities of each installation should be studied carefully, and the cylinder oil selected which will most satisfactorily take care of them. This requires a thorough understanding of the properties of oils and of the effect of mechanical and steam conditions upon them.

Five Factors Influencing Lubrication. In the selection of the correct steam cylinder oil, five influencing factors are to be considered:

Steam pressure
Steam Quality (wet, dry, or superheated)
Engine Load
Engine Size
Engine Speed

These items must all be noted in making a survey of power plant for lubrication recommendations, as well as the method of applying the lubricant in each case.

COMBUSTION TOPICS

Furnace repairs add approximately one dollar to the cost of each ton of steel produced. From the standpoint of design, operation and maintenance, a goodly proportion of our readers are vitally interested in this item of cost. To meet this interest, we start our new department, "Combustion Topics", with a series of informative articles on furnace materials, beginning with the most important item, refractories.

Continued from March Issue

DATA ON REFRACTORY MATERIALS

FIREBRICK:

The materials used in making firebrick are flint clay, plastic clay and calcined clay, in varying proportions, depending on the character and quality of brick to be made. The first gives refractoriness and low drying shrinkage, the second, strength, and the last diminishes drying and burning shrinkage.

Chemical analyses of firebrick usually fall within the following limits:

Silica	50.0 — 65.0%
Alumina	20.0 — 45.0%
Ferric Oxide	1.0 — 3.0%
Lime	.1 — 1.5%
Magnesia	.1 — 1.0%
Potash and Soda	.1 — 2.0%

Firebrick are burned at temperatures up to 2600° F., the degree of burning usually being indicated by the terms "hard burn", "medium to hard", "medium", and "light to medium".

The specific gravity of firebrick may run from 2 to 2.75, depending on composition and method of manufacture. This corresponds to densities of 125 to 172 pounds per cubic foot. The higher the alumina content, the greater the specific gravity. Machine made bricks are more dense than hand made bricks, and hard-burned more dense than light-burned brick.

Strength of firebrick may vary between wide limits, being greater for machine made than for hand made brick, and greater for hard burned than for light burned brick of the same clay mixture. First quality brick may vary from 1000 to 3000 pounds per square inch, crushed on end, and plastic clay brick may run up as high as 5000 pounds per square inch.

The actual crushing strength of a brick depends on the direction it is loaded, being lowest when loaded on end, and highest when loaded flat.

The effect of temperature on crushing strength is indicated by the following results:

Crushing Strength Pounds Per Square Inch	Temperature °F.
980	400
1025	800
1070	1200
1120	1600
1100	1800
450	2000
50	2100
35	2400

However, deformation occurs at temperatures much below the melting point, in a degree depending on time, temperature and load. Hard-burned brick deform less than those of light-burn, while higher silica content tends to decrease deformation.

Fusion point may vary from 2700 to 3100 degrees F.

Specific heat of firebrick may be approximated from the formula:

$$\text{Specific Heat} = .195 + .00003\ t\ °F.$$

Porosity of firebrick may run from 30% to 15% or even lower. Certain clays produce brick of very low porosity, and machine-made, hard-burned bricks show lower porosity.

Heat conductivity of all brick varies with its porosity, permeability, temperature of burning, and temperature at which it is used. An average value for firebrick may be obtained from the following formula:

$$\text{BTU/hour/square foot/°F/inch} = 5.5 + .0025\ t\ °F.$$

Thermal expansion for firebrick in the usual temperature range of furnaces may be taken as 1/16-inch per foot.

Electrical resistivity of firebrick is approximately as follows:

1500° F.	50,000 ohms per c.c.
1800° F.	11,700 ohms per c.c.
2000° F.	6,800 ohms per c.c.
2200° F.	4,200 ohms per c.c.
2400° F.	2,400 ohms per c.c.

As silica is in the majority of cases predominant, the character of firebrick is acid. Texture and method of manufacture influence its reaction with basic slags, such as iron oxide. Fine, hard-burned brick have greater resistance to abrasion and slag action. Coarser brick, with lighter burn, can better withstand sudden temperature changes, and therefore posses greater resistance to spalling, but they are rapidly attacked by slag. Firebrick is therefore of doubtful value for furnace bottoms where steel is heated to rolling temperatures, unless scale formation is very light. It can be used for roofs and sidewalls of such furnaces, or for the entire construction of heat-treating or other low temperature furnaces.

SILICA BRICK:

Silica brick is made from quartzite, low in impurities, with a little lime added. Burning at 2600 to 2800° F. converts the quartzite to other forms of silica of lower specific gravities, and the brick therefore undergoes a permanent expansion of 3/8 to 7/16-inch per foot. This conversion can be hastened by burning at high temperature, or it can be completed

by a longer burn at lower temperature, which is preferable.

Chemical analyses of silica brick are somewhat as follows:

Silica	94.0 to 96.0%
Alumina	.5 to 1.0%
Iron Oxide	.3 to 1.0%
Lime	1.5 to 3.0%
Magnesia	.1 to .4%
Potash and Soda	.1 to 1.0%

Silica brick has a density of 90 to 110 pounds per cubic foot, and a specific gravity of 2.3 to 2.4. If incompletely burned, the specific gravity may be as much as 2.6, but the lower values are desirable.

Silica brick may withstand crushing stresses of 1000 to 2000 pounds per square inch on end, cold. Under higher temperatures, its strength falls off as follows:

Crushing Strength Pounds Per Square Inch	Temperature °F.
1800	900
1600	1400
1300	1900
800	2200
300	2600

Silica brick is soft and usually fails by shearing, due to the weakness of its bond.

The fusion point of silica brick is 3000 to 3200° F., approximately the same as for first grade firebrick, but it retains greater strength much longer than firebrick.

Specific heat of silica brick is approximately as follows:

$$\text{Specific Heat} = .2 + .00005\ t\ °F.$$

Porosity of silica brick runs from 18% to 40%. For heat resistance alone, porosity is not undesirable, but lower porosity is desirable for resistance to abrasion.

Heat conductivity can be approximated as follows:

$$\text{BTU/hour/square foot/°F./inch} = 6 + .0035\ t\ °F.$$

In furnace construction, provision for expansion of silica brick should be made at the rate of 1/8 to 3/16-inch per foot. This expansion begins gradually, increases very sharply at about 400° F., and reaches its maximum of about 3/16-inch per foot at 1250° F., beyond which they are almost constant in volume. Due to the rapid expansion between these two points, heating and cooling through this range must progress very slowly if cracking and spalling are to be avoided. The use of silica brick should be avoided in furnaces which will be subject to intermittent operations.

Electrical resistivity of silica brick is as follows:

1900° F.	190,000 ohms per c.c.
2100° F.	90,000 ohms per c.c.
2300° F.	39,000 ohms per c.c.
2500° F.	20,000 ohms per c.c.
2600° F.	13,600 ohms per c.c.
2700° F.	9,800 ohms per c.c.

Due to the difference in expansion of silica brick and firebrick, it is inadvisable to bond silica brick with firebrick.

Resistance to abrasion and to chemical action is low.

MAGNESIA BRICK:

Magnesia brick is made from the mineral magnesite, in crystalline form. This mineral is "dead burned" to drive off the CO_2, ground fine, mixed with a small quantity of water and formed into bricks, no binder being used. They are burned at 2600 to 2900° F.

Magnesia brick has a chemical analyses as follows:

Magnesia	85.0 to 95.0%
Alumina	1.0 to 3.0%
Iron Oxide	Trace to 8.0%
Lime	Trace to 3.0%
Silica	1.0 to 5.0%

With a moderately coarse texture, magnesite brick has a true specific gravity of 3.05 to 3.58, depending on the burn and the impurities present. The denser brick is usually of superior grade. Incomplete burning lowers the specific gravity. A density of 163 to 173 pounds per cubic foot indicates an apparent gravity of 2.6 to 2.75.

Magnesia brick when cold is very strong, having a crushing strength of 4,000 to 6,000 pounds per square inch. This strength is maintained up to fairly high temperatures, but at 2300 to 2600° F., the strength drops off with extreme rapidity. It should therefore not be generally used under heavy load above 2350° F. The following gives evidence of this:

Crushing Strength Pounds Per Square Inch	Temperature °F.
5400	800
4700	1600
4200	2000
3800	2200
1500	2400
100	2600

Magnesia brick fuses from 3200 to 3600° F.

Specific heat can be determined from the following:

$$\text{Specific Heat} = .21 + .00006\ t\ °F.$$

Porosity may run from 20 to 30% of volume. The more porous brick is not so sensitive to sudden temperature change.

Heat conductivity of magnesite brick is about as follows:

$$\text{BTU/hour/square foot/°F./inch} = 40 - .0065\ t\ °F.$$

Due to the high heat conductivity it is usually necessary to back up magnesite bricks with firebrick to prevent overheating of the steel frame work of furnaces.

Provision for expansion should be made at the rate of about 3/16-inch per foot. This expansion is more gradual than that of silica brick, but total expansion is somewhat higher. However, if exposed to rapid heating or cooling, they spall badly, apparently at all temperatures.

Electrical resistivity is as follows:

2200° F.	184,000 ohms per c.c.
2400° F.	58,000 ohms per c.c.
2600° F.	16,000 ohms per c.c.
2700° F.	4,800 ohms per c.c.

Magnesia bricks are essentially basic in character, and are not effected by heating in contact with basic slags. Blast furnace slag, however, is very corrosive. Carbon rapidly corrodes or pits any magnesia brick surface. Resistance to abrasion is very low. The pure brick is very friable, becoming less so as impurities increase.

Fully shrunk magnesia brick is not as sensitive to sudden temperature changes as silica brick is, but there is a marked tendency to spall. A metal casing is sometimes used on magnesia brick to diminish spalling, and some mechanical strength is gained thereby. Shrinkage is very low in brick of good grade, but increases in the poorer grades.

Magnesia brick is used for hearths over which hot steel moves, as in drop forging, or other high temperature operations. They are also employed to a considerable extent in open hearth furnaces. It is not considered good practice to place magnesia brick in contact with silica or fireclay brick, due to their respective basic and acidic characteristics. A course of neutral chrome brick is usually placed between.

CHROME BRICK:

Chrome brick are made from the mineral chromite, which may contain from 50 to 60% Cr_2O_3. The method of manufacture is similar to that for magnesia brick, and they are burned slowly at 2650 to 2950° F. and cooled slowly.

Chemical analyses will fall within the following limits:

Chromic Oxide	35 to 60%
Iron Oxide	15 to 30%
Alumina	2 to 25%
Silica	2 to 8%
Magnesia	1 to 15%
Lime	1 to 5%

Chrome brick weighs 175 to 190 pounds per cubic foot, pointing to an apparent specific gravity of 2.8 to 3.05. True density is about 3.8.

The strength of chrome brick is very comparable to that of magnesia brick, and their behavior under temperature is very similar.

Chrome brick melts about 3700° F., but softens at 3100 to 3400° F. Due to disintegration, it cannot be used much above 2700° F. Clay bonded brick are less refractory than those in which lime is used with the pure chrome ore.

Specific heat is as follows:

Specific Heat = .17 + .000023 t °F.

Porosity is usually about 20 to 30%.

Heat conductivity of chrome brick can be approximated as follows:

BTU/hour/square foot/°F./inch = 10 + .004 t °F.

Provision for expansion should be at the rate of 5/32 to 7/32-inch per foot. This expansion occurs gradually over the entire temperature range, similar to that of magnesia brick.

Electrical resistivity is approximately as follows:

1500° F.	650 ohms per c.c.
1800° F.	150 ohms per c.c.
2400° F.	150 ohms per c.c.

The chemically neutral characteristics of chrome brick render them particularly useful. They are not attacked by iron oxide, and are therefore excellent as a hearth covering in high temperature furnaces. They are also used in open hearth construction.

CARBORUNDUM BRICK:

Silicon carbide is made in electric furnaces of compounds of silica and carbon. This material is then bonded by clay and lime into bricks, and reburned at temperatures of 2600 to 3300° F. Chemical analyses usually fall within the following limits:

Silicon Carbide	75 to 98%
Silica	1 to 20%
Alumina	1 to 5%
Iron Oxide	Trace to 1%

Carborundum refractories have a density of 135 to 165 pounds per cubic foot, an apparent specific gravity of 2.1 to 2.6.

Compressive strength varies with the amount of silicon carbide present. Cold crushing strength is about 12,000 pounds per square inch, and the strength is retained up to very high temperatures. Compressive stresses of 50 pounds produce no sign of failure at 3000° F.

Specific heat is approximately .17 x .00001 t °F.

Heat conductivity varies widely according to the percent of silicon carbide present. However, an average value of 65 + .01 t °F. BTU/hour/square foot/°F./inch will be close enough for most purposes.

Expansion should be allowed for at a rate of 1/16-inch per foot, approximately the same as firebrick, to which it can be bonded in ordinary heating furnace construction.

Electrical resistivity is as follows:

1800° F.	7500 ohms per c.c.
2000° F.	6300 ohms per c.c.
2200° F.	4100 ohms per c.c.
2500° F.	1450 ohms per c.c.
2700° F.	750 ohms per c.c.

Carborundum refractories may decompose when heated in contact with air, and their strength may drop off with continued use. At temperatures usually prevailing, however, a brown impervious glaze of silica forms on exposed surfaces which protects the material and maintains load-capacity. Resistance to abrasion is very great. Spalling is negligible except under very high temperature with expansion prevented. Basic slags, high in iron, cause rapid disintegration.

The characteristics of carborundum refractories render them particularly useful for muffles, hearths of underfired furnaces, or wherever high conductivity is desired. They are also very useful for supporting piers subject to high temperatures, and for any very high temperature application requiring strength or resistance to abrasion, without the presence of basic slags or molten iron.

▲

ASSOCIATION NOTES

Seven hundred Steel Mill Executives and Operators traveled a total of 50,000 miles on March 24th to Youngstown, Ohio, to attend an Engineering Conference on Sheet Mill Practices, sponsored by the Association of Iron & Steel Electrical Engineers.

The May issue of the IRON AND STEEL will contain the papers and discussion presented at this meeting. The subjects covered included Gas Cleaning, Uses of Gases, Continuous Heating Furnaces, Improvements in Sheet Mill Practices, the Combination Method, the Combination System and New Designs in Electrical Motors and Control Apparatus with Characteristics to permit 40 or more reversals per minute.

Savings Accomplished With Foot-Operated Master Switches

▲

By W. H. BURR

Electrical Superintendent, Lukens Steel Co., Coatesville, Pa.

Presented before Philadelphia Section, Association of Iron and Steel Electrical Engineers, April, 1932.

Recently, we have made certain changes in the operation of the 84" Tandem Plate Mill, at Lukens Steel Co., which may be of interest to the operating men here tonight.

The layout in this mill consists of an approach table on which the charging crane delivers the slabs or the ingots.

Inasmuch as the Roughing Stand of this Tandem Mill is driven by a 1200 H.P., D.C., reversing motor, the front and back tables are of the non-tilting type. Double drive motors are used on the screw down on this mill, and an adjusting motor is used for leveling the mill. The back, or the runout table, is driven by two motors, one on each side; rollers 1-3-5-7 are driven by one motor, rollers 2-4-6-8 by the other, which makes it possible to rotate this plate back of the roughing stand, in order to facilitate rolling it to the proper width. An intermediate table is located between the two stands.

The Finishing Mill is also driven by a D.C. reversing motor, 25000 H.P. capacity. Front and back tables are again of the stationary type. Double motor drive is used on Finishing Mill screw down, together with leveling motor for adjusting the mill.

At the right hand side of this layout, between the Roughing Mill and Finishing Mill, the operating pulpit is located. The mill operators are on the second floor, so to speak, which allows room for the roller and helpers directly under the operators.

The crew for operating this mill consists of a roller, who supervises the complete rolling operation; a scale blower, and an operator on Roughing Mill and a similar crew on the Finishing Mill. We will concern ourselves principally with the operators on each stand.

On the Roughing Mill, the operator controls the approach table, front and back tables, main drive motor, screw down motors, the mill leveling motor, rotation of the plate back of the mill, and under certain conditions, the intermediate table. This makes a total of nine motors under his control. The approach table control is operated with his left hand, and is used only once during the rolling of an ingot. Front and back table controls are also at his left and operated with his left hand. The main drive motor is controlled by a foot-operated master switch and the screw down motors are operated with his right hand. Turning of the plate on the back table is accomplished by pressing with his thumb on a push button switch located in the handle of the back table controller. This makes it possible for the operator to run these two motors on the back table in the opposite directions and still have the table controller in the forward or reverse position during this operation. By means of a drum controller, the intermediate table can be operated by either the Roughing Mill operator or the Finishing Mill operator in case the plate is of such length that both the back table and the intermediate table are required to handle an extra long plate.

The Finishing Mill operator has practically the same equipment to control, with the exception of the turning operation, which is not required on the Finishing Mill. The adjusting or leveling control is located above the operator such that he simply reaches up and operates this control when it is necessary to level the rolls in the mill.

The schedule in this mill, under certain conditions calls for finishing a plate every minute. On the Roughing Stand, a minimum of five passes is usually required. For each pass, an average of six distinct operations are necessary. This means that the operator is called upon to perform an operation every two seconds, every time the mill is rolling under this schedule. The problem on such a mill is not electrical or mechanical, but one involving the human element.

These operators work on an eight-hour shift and the average day's schedule does not call for rolling a plate a minute during the whole eight-hour shift. On the larger and heavier sizes, the schedule drops to as low as three plates every five minutes. Even then, the operator does not have to look for outside entertainment to occupy his time.

When the mill is working on a twenty-four hour schedule this change has resulted in saving six operators per day.

MESSAGES FROM PAST PRESIDENTS OF THE A. I. & S. E. E.

(Continued from Page 160)

Many of the men have been members of the profession throughout the life of the A. I. & S. E. E. and have been a part of the great progress electricity has played in the developments in modern steel mills.

To them the Steel Industry is obligated for many of its modern applications for quality as well as quantity production and they, in turn, are obligated to the A. I. & S. E. E. for a means of correlating and developing ideas which perhaps had a humble beginning in some armature repair shop. Back in 1907 we find that many plants believed certain secrets existed regarding motors and controls that should not be revealed to competing firms. This was revealed in the many home-made control schemes that have long since been discarded.

When the Association meetings proved themselves a place for advancement in their ideas, the attitude of secrecy was replaced by one of co-operation and from this beginning, we have the wonderful development of steel mill electrification that is so familiar to all of us.

As a part of this development, the advantages of a standardization of parts and apparatus was a natural result. Back in 1908 it was realized that overhead traveling cranes contained about all possible sizes of wheels, shafting, gears, etc., but the co-operative spirit was not strong enough to put the crane code across. This was not done until years later, but we now have overhead traveling cranes standardized, so that they can be economically built by several manufacturers and the spare parts required are reduced to a minimum.

We have also seen the A. I. & S. E. E. standard mill motor realized and in the near future will see progress in the general purpose motors. These are of great advantage to machinery builders and in turn a large factor in keeping electrical inventories to a minimum.

Another far reaching accomplishment was the work done by the Special Committe on Bearings. Through their efforts the application of anti-friction bearings was changed from a mystery to a simple study of standardized tables and has resulted in the elimination of many troubles that were caused by misapplication.

At the present time the Control Committee is making progress in standardizing the basic parts of this type of apparatus. They have hopes of securing an agreement whereby wiring diagrams will be similar in appearance, dimensions of boards uniform and many other advantages that will be appreciated by the steel mill operators.

The foregoing examples of accomplishments will grow in importance as time goes on. The necessity for lower operating costs and lower inventories has a direct relation to standardization. The obsolete equipment that has stood the rigors of steel mill existence is rapidly passing out of the picture. It is being replaced by modern standardized equipment. In the future the work of committees on these subjects should be more easily accomplished, since the advantages are realized by all.

Of the many things our Association has to be proud of during the twenty-five years of its existence, I believe its pioneering in standardization will rank as one of the outstanding results.

By C. S. PROUDFOOT
President of the A. I. & S. E. E., 1928-1929.

Why is the A. I. & S. E. E.? Why is any association?

In the vast majority of instances, what is the motivating principle that prompts any group of serious business men to establish an association within their ranks? Isn't it purely and simply for the prime purpose of exchanging ideas?

Unquestionably, there are other worthy purposes and ideals upon which many associations are founded . . . the defense of a cause or the propagation of a belief . . . but these enterprises are intrinsically social, and their benefits definitely single-fold.

The basic principle of a business association, however, is of a broader nature—that is, in the bringing together as often as practicable the leading minds of an industry, a business, a profession or even a field of thought, that they may compare notes, discuss trends and experiments, and exchange ideas to their mutual benefit.

A little more than a quarter of a century ago, an inspired group of electrical engineers in the iron and steel industry came together and founded the A. I. & S. E. E., upon the fundamental principle that in the exchange of ideas there is knowledge and progress for all.

Who among those broad-visioned founders, even in his fondest dream, ever dared imagine the Association would achieve the phenomenal success it has?

So sound was the purpose of the Association, and so intense the zeal of its members, that in the succeeding years the A. I. & S. E. E. has attracted to its fold practically every prominent engineering mind in the industry. And today, as always, every member is true to the principle upon which the Association was conceived—the exchange of ideas.

You hold the evidence . . . the magazine you are reading at this very moment is, in itself, ample evidence of the adherence of our members to the principle of exchanging ideas. The "Iron and Steel Engineer" is a lasting monument to the unselfish efforts of the Association's members to impart to their fellows every bit of helpful knowledge they gain, either through experiment or experience.

Think back over the years you have been reading the Iron and Steel Engineer. Consider the hundreds of articles you have read, and found both interesting and valuable. Did you ever stop to think why this or that article was written? Have you ever really recognized the true cause and the full importance of this, our Association's own private publication?

Every iron and steel mill has its own peculiar problems, many of them are common to the whole industry. Day in and day out old problems are solved, while new difficulties arise. And the discussions and solutions of these problems are forthwith published in the Iron and Steel Engineer, with the findings of the plant's engineers who have worked days, weeks or perhaps years to solve some particularly irksome industrial evil.

Perhaps a certain plant engineer discovers a method to overcome some minor detail of production. Perhaps some engineer evolves a new plan entirely revolutionizing some branch of production, refining, loading or shipment. It does not matter

how small or great the solution, or discovery; the fruit of their labors is yours for the reading.

In addition, we have our various committees which test devices and probe new ideas that were designed as improvements in some branch or other of the industry. These committees are composed of men specifically trained and especially fitted to determine the true value of a new device or idea. The work of these research committees has proven of inestimable value to the entire iron and steel industry.

And their reports and findings are recorded in The Iron and Steel Engineer, that every member of the Association may benefit thereof.

Aside from this perhaps more serious aspect, the A. I. & S. E. E. has the value of bringing together iron and steel engineers . . . men who speak the same language . . . from all parts of the country. Engineering is the life work of our members, and it is the one topic they love to introduce into a conversation wherever possible, regardless of the occasion or the surroundings . . . much like the postman who insists upon long walks on his days off.

Consider, too, the phenomenal financial condition of the Association. It should make us all feel good to know that we are all associated with an organization that has money in the bank, good credit and getting stronger every day.

ITEMS OF INTEREST

PERSONNEL CHANGES

Walter de Fries, recently identified with the William B. Pollock Company, Youngstown, O., has joined the Pittsburgh Steel Foundry Corporation, Glassport, Pa., in a special sales engineering capacity. Mr. de Fries was in charge of engineering of steel plate construction with the Pollock company, previously having been associated with the Wellman Engineering Company, Cleveland.

James S. Fraser, since 1920 general superintendent of the Trumbull-Cliffs Furnace Company, Warren, O., has tendered his resignation effective April 1, to join the staff of H. A. Brassert & Company, Chicago. He is to take an active part in the company's consulting and operating work abroad. A. J. Hulse, heretofore assistant chief engineer of the Brassert company, has been appointed chief engineer, succeeding Frederick Wille, who has resigned. C. E. Dougan, who has been chief draftsman, has become assistant chief engineer.

Frank L. Estep, vice president, Perin Engineering Company, consulting engineers, New York, sailed April 8 for India, in connection with steel plant improvements and additions for the Tata Iron and Steel Company, Jamshedpur, India.

Colonel J. S. Ervin has been elected president and a director of the Mackintosh-Hemphill Company, Pittsburgh, Pa. H. V. Blaxter is chairman of the board and F. Hughes Moyer has been elected vice president and senior engineering officer.

Charles V. Fish has been appointed by the Reliance Electric & Engineering Company, Cleveland, O., manufacturers of alternating and direct-current motors, to represent them in Allentown and Northeastern Pennsylvania. He will be located at 515 North Lafayette street, Allentown, Pa.

The Penn Union Electric Corporation of Erie, Pa., has appointed Millard S. Robinson as their Pittsburgh district manager with headquarters at 502 Oliver Building, Pittsburgh, Pa. Mr. Robinson is also associated with the Erie Malleable Iron Company.

H. M. Ludwick, who was formerly with the Keystone Lubricating Company, has severed his connections with that company and is now sales engineer with the Trabon Lubricating Equipment Company of Detroit, located at 401 North Broad street, Philadelphia.

The Reliance Electric & Engineering Company, Cleveland, O., manufacturers of alternating and direct-current motors, have established a sales branch at 703 Bona Allen Building, at Atlanta, Ga., in charge of Marshall Whitman and George Gardner. The territory covered from this point will be North and South Carolina and Georgia.

Nelson W. Pickering was re-elected president of the Farrel-Birmingham Company, Inc., Ansonia, Conn. He has been identified with that company and its predecessor, the Farrel Foundry & Machine Company, during all of his civilian business career.

William S. Wilbraham, who has been in charge of the Estimating and Order Department at Lukenweld, Inc., Coatesville, Pa., since this organization was established in 1929 to manufacture welded parts for machinery and equipment, has been appointed assistant manager of sales, and will work directly with Henry H. Peck, manager of sales for Lukenweld, Inc.

WITH THE MANUFACTURERS

National Carbon Company, Inc., Carbon Sales Division, Cleveland, O., has recently announced a new electrographitic brush known as National Pyramid Grade No. 234, the unique characteristic of which is a non-resilient structure—a property which enables the brush to maintain exceptionally firm contact on commutators of high peripheral speed. The field of application of this new grade as stated in the announcement is for heavy duty direct current generating and substation equipment.

A four-page bulletin No. 3017 on "Surge Proof Distribution Transformers" is now ready for distribution. Copies of this well illustrated bulletin

may be secured by writing Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

▲

The Century Electric Company, Inc., St. Louis, Mo., has developed a new line of Brush Riding Single Phase Repulsion Start Induction Motors, intended primarily for those applications where the most quiet operation or the higher operating characteristics are not required.

This line of motors is not intended to replace the well-known line of Century Brush Lifting Motors which will continue to be supplied for long hour per year applications, such as, refrigerators, oil burners, etc.

▲

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., is now distributing bulletin C-1937 on Type AB "De-Ion" Circuit Breakers. Copy of this bulletin may be secured by writing the above company.

▲

The Una Welding and Bonding Company, Cleveland, O., are distributing a new booklet on Una—The Modern Arc Welder, Dynamotor Construction. This 16-page booklet contains valuable information on welders and the field of application. Copies may be secured by writing the above concern.

▲

Jefferson Electric Company is distributing a new eight-page folder which illustrates photographically the new plant recently completed, located in Bellwood, a suburb just west of Chicago.

▲

A new pyrometer lamp which measures within five to ten degrees centigrade of the temperature of a furnace has been developed by the Nela Park Lamp Development Laboratories of the General Electric Company, Cleveland, O., and is now in use in the company's lamp factories.

▲

"Apparatus for Electrical Resistance Measurements" is the title of a completely revised edition of catalog No. 40 issued by the Leeds & Northrup Company of Philadelphia, Pa. Copy of this 32-page catalog may be secured by writing the above company.

▲

The Ohio Electric Mfg. Co. of Cleveland, O., have prepared for distribution an attractive four-page folder on special motors. The Bulletin No. 211 which is well illustrated gives a few of these special designs giving dimensions and horsepower. Copy of this bulletin can be obtained by writing the above concern.

▲

"Recording Absolute Pressure Gauges" is the title of a 12-page bulletin now ready for distribution by The Bristol Company, Waterbury, Conn. Copy of this interesting bulletin may be obtained by writing the above company for Bulletin No. 1011, supplementary to No. 1010.

▲

The Benjamin Electric Manufacturing Company, Des Plaines, Ill., has placed on the market the "Mobilite", a weatherproof enamel floodlight, mounted on a free-rolling, three-wheeled truck.

POSITIONS WANTED

A steel mill electrical engineer, with 16 years of steel mill experience, is open for a position either in engineering or operating supervision work, sales or drafting work.

He is a graduate of the Ohio State University and has had full charge of electrical construction work on rod and billet mills and many years of experience in operating electrical departments.

Address: Engineer, c/o Iron and Steel Engineer, 1010 Empire Building, Pittsburgh, Pa.

▲

An electrical engineer, with 32 years experience in various steel plants in United States, is open for a position with any plant that desires an operating executive to supervise or operate an electrical department.

He has had five years experience in erecting and wiring cranes, ore bridges and ore unloaders; two years experience in the construction of the Panama Canal; has been chief electrician of one of the large steel plants in America and has had two years consulting experience with a large steel plant.

Address: J, c/o Iron and Steel Engineer, 1010 Empire Building, Pittsburgh, Pa.

▲

OBITUARY

William F. Rese, formerly chief electrical engineer of the Great Lakes Steel Corporation, Ecorse, Mich., died March 26, 1932.

Mr. Rese was formerly connected with the Trumbull Steel Company at Warren, O., where he was employed in the capacity of chief electrical engineer for many years.

Mr. Rese was an active member of the Cleveland District Section of the A. I. & S. E. E.

The members of the Association extend their sympathies and condolences to the relatives of this well known engineer.

▲

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

IRON AND STEEL ENGINEER

(Required by Act of Congress of August 24, 1912)

Name of Publication: Iron and Steel Engineer, published monthly at Pittsburgh, Pa. (Report of April 1, 1932).
Editor—John F. Kelly, Empire Bldg., Pittsburgh, Pa.
Business Manager—John F. Kelly, Empire Bldg., Pittsburgh, Pa.
Names and addresses of stockholders holding 1 per cent or more of total amount of stock: None.

Board of Directors

President, J. J. Booth, National Tube Co., Gary, Ind.
First Vice President, J. D. Donovan, Republic Steel Corp., Massillon, O.
Second Vice President, W. E. Miller, Bethlehem Steel Co., Johnstown, Pa.
Treasurer, Walter H. Burr, Lukens Steel Co., Coatesville, Pa.
Secretary, William Jackson, Homestead Steel Works, Carnegie Steel Co., Munhall, Pa.
Past President, F. O. Schnure, Bethlehem Steel Co., Sparrows Point, Md.
Past President, F. W. Cramer, Republic Steel Corp., Youngstown, O.
Director at Large, J. H. Van Campen, Republic Steel Corp., Youngstown, O.
Director, K. M. Raynor, Bethlehem Steel Co., Bethlehem, Pa.
Director, G. T. Hollett, Illinois Steel Co., South Chicago, Ill.
Director, G. R. Carroll, Jones and Laughlin Steel Corp., Aliquippa, Pa.
Director, C. C. Pecu, Bethlehem Steel Co., Lackawanna, N. Y.
Director, B. Thele, Tennessee Coal, Iron and R. R. Co., Fairfield, Ala.
Director, J. F. Hunter, Carnegie Steel Co., Pittsburgh, Pa.
Director, J. H. Wagner, Acme Steel Co., Chicago, Ill.
Director, J. A. Clauss, Great Lakes Steel Corp., Ecorse, Mich.
Honorary Director, J. Farrington, Wheeling Steel Corp., Steubenville, O.
Honorary Director, E. Friedlander, Pittsburgh, Pa.
Known bondholders, mortgagees and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages or other securities: None.

JOHN F. KELLY, Editor.

Sworn to and subscribed before me this 24th day of March, 1932.
HENRY W. BALDWIN, Notary Public.
(My commission expires April 18th, 1933).